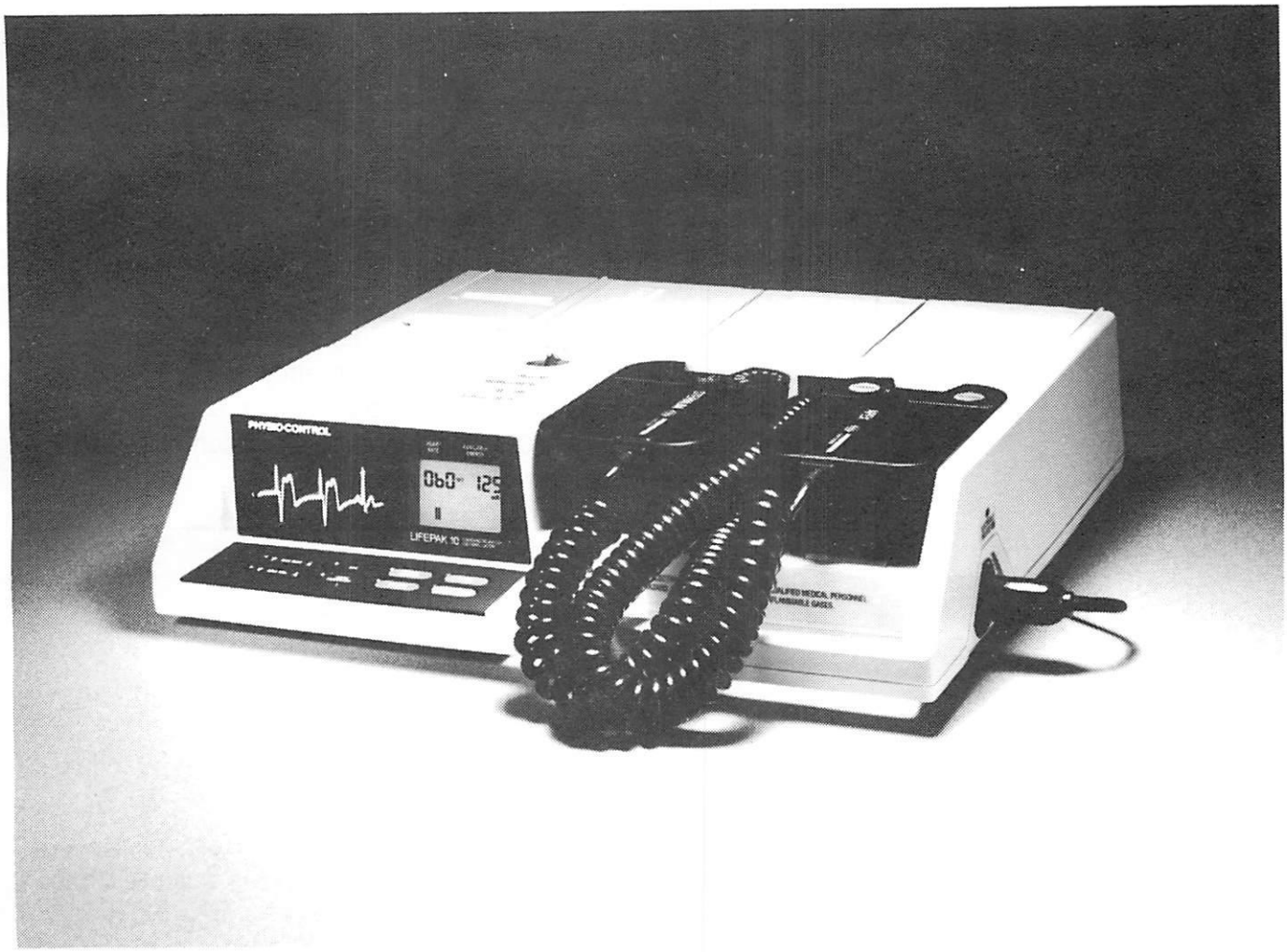
PHYSIO CONTROL

LIFEPAK® 10 defibrillator/monitor/pacemaker



Service Manual

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PART NO. _____

SERIAL NO. _____

About This Manual: This Service Manual is intended for use by technical service personnel. It describes how to maintain, test, troubleshoot, and repair the LIFEPAK 10 defibrillator/ monitor/pacemaker.

A separate publication, the ***Operating Instructions***, is intended for use by physicians, clinicians, and emergency care personnel. It provides step-by-step instructions for all operating features of the LIFEPAK 10 defibrillator/monitor/pacemaker as well as operator-level testing and maintenance.

Trademarks

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Warranty

Refer to the product warranty statement included in the accessory kit shipped with the product for information about the warranty. Duplicate copies may be obtained from the local Physio-Control Sales and Service office.

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Safety Information

Introduction

This safety information includes terms and symbols used in this manual or on the equipment to alert both operating and service personnel of recommended precautions in care, use and handling of this specialized medical equipment.

Refer to NFPA (National Fire Protection Association) 99-1990, *Health Care Facilities*, and NFPA 70-1990, *National Electrical Code*, for specific guidelines on the standards and practices for health-care instruments and environments.

Terms

Certain terms are used in this manual, or on the equipment. Familiarize yourself with their definitions and significance.

Danger: Immediate hazards which **will** result in serious personal injury or death.

Warning: Hazards or unsafe practices which **could** result in serious personal injury or death.

Caution: Hazards or unsafe practices which **could** result in minor personal injury or product damage.

Note: Points of particular interest for more efficient or convenient instrument operation. Additional information or explanation concerning the subject under discussion.

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Warnings

Following are descriptions of general hazards and unsafe practices that could result in death, serious injury or product damage. Specific warnings and cautions not appearing in this section are found throughout the manual.

Possible Fire or Explosion

Do not operate this product in oxygen-enriched environments or in the presence of flammable gases or anesthetics. Explosion or fire can result. Refer to NFPA (National Fire Protection Association) 99-1990, *Health Care Facilities*, and NFPA 70-1990, *National Electrical Code*, before operating this product in the proximity of flammable gases or anesthetics.

Safety Hazard

Do not mount the product directly above the patient. Place the product in a location where it cannot harm the patient if it should fall from its shelf or other mounting location.

Electrical Hazard

Do not operate equipment using damaged cables and wires. Broken or frayed wires, or loose snap fittings may cause interference or loss of signal. Perform frequent electrical and visual inspections on cables and wires. Pay particular attention to the point at which the wires enter the terminals. Repeated flexing at these points eventually causes the wire strands to break.

Possible Shock or Fire Hazard

Do not immerse any portion of the instrument in water or other fluids. Fluid spills and splashes may damage the instrument's electrical components.

Possible Equipment Damage

Do not sterilize this product. Sterilization environments can cause serious damage. Do not autoclave or gas sterilize accessories unless manufacturer instructions clearly approve it.

Possible Safety Risk

Do not substitute accessories. Use only recommended accessories listed in Table 5–3 shown on page 5–5. Substitution may cause the instrument to work improperly.

Shock or Fire Hazard

Make sure that all equipment is interconnected safely in accordance with NFPA (National Fire Protection Association) 70-1990, *National Electrical Code*.

> ***Note:*** *Within certain governmental jurisdictions, all interconnected accessory equipment must be labeled by an approved testing laboratory. It is important that you verify and observe the required applications in your location. Check leakage current and grounding requirements after interconnecting this instrument with accessory equipment.*

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Symbols

Any or all of the following symbols may appear in this manual or on the equipment:

Static Sensitive Device (SSD)

Additional information in Section 6, Component References

DANGER — high voltage present

This symbol has a different meaning on equipment labels and on the monitor display:

1. On equipment labels: **ATTENTION** — refer to manual for more information.
2. On the monitor display: **ATTENTION** — Service Indicator. This appears and remains on if any of the built-in tests encounters a possible failure. Indicates the need for prompt service or repair if it remains on. May flash briefly after paddle discharge buttons are pushed.

Defibrillation protected, type CF patient connection

Defibrillation protected, type BF patient connection

Protective ground (earth) terminal

Fusible Link

Equipotentiality connector

Off (Power: disconnection from the AC mains)

On (Power: connection to the AC mains)

ECG Output

Recyclable battery

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General Information

Service Information

Before attempting to clean or repair any assembly in this instrument, the technician should be familiar with the information provided in Section 4, **Service and Maintenance**.

If the instrument has been dropped, damaged, or abused, a qualified technician should complete the **Performance Inspection Procedure (PIP)** in Section 3 to confirm whether the instrument is operating within specifications. If calibration or more extensive testing is required, a qualified technician can perform the **Test and Calibration Procedure (TCP)** in Section 3. Component replacement and internal adjustments must be performed only by service personnel qualified by appropriate training and experience.

The use of defibrillation electrodes, pacing electrodes, or adapter devices from sources other than Physio-Control is not recommended. *If instrument failure is attributed to accessories not manufactured by Physio-Control, the warranty may be voided.*

For assistance in servicing the instrument in the U.S., call Physio-Control at 1-800-442-1142. In other countries contact the local Physio-Control representative.

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Effective Publication Dates

The effective publication date for each page of this manual is listed below.

Title	Page	Effective Publication Date
Trademark and Warranty	ii	May 1993
Table of Contents	iii thru xi	May 1993
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List of Tables	x thru xi	May 1993
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6 Component Reference Diagrams	6-1 thru 6–16	May 1993
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Configuration Information

This manual is current with the listed revision level of the following part numbers. The assemblies appear in the same order as in Table 5-1.

Assembly Name	Part Number	Rev
Final Assembly	804200-00 thru -46	J1
Recorder Assembly	804189-00	B1
Paddle Assembly	804250-01 thru -08	D
Status Display Module	805230-01	B
Relay Assembly	800240-12	U2
System PCB Assembly	804204-01 thru -05, -08 thru -15	B21
Chart/Pacer PCB Assembly	804202-02 thru -09, -12, and -13	E3
Anode Power Supply	804296-05	C2
Main Control Panel Assembly	804277-01 thru -04	C1
Pacer Control/Battery Indicator Panel Assembly	804196-01, -05 thru -09	D2
Energy Select PCB Assembly	804258-02	A
CRT Assembly	805180-00	B3
CRT PFC	805078-01	D9
MIEMSS Modulator PCB Assembly	805608-01	B7
Wire Harnesses (W1-W11)	805115-00 thru -15	D
Wire Harness (W12)	804249-00	B3
Wire Harness (W13)	804252-01	B3
Wire Harness (W14)	804253-00	B
Wire Harness (W15)	805628-00	Orig3
Wire Harness (W16)	805629-01	A
12 Lead ECG Adapter	805600-00 thru -06	A3

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Overview of this Manual

This manual contains the following information:

Section 1

Description: This section details how the instrument works. Input signals, power supplies, PCB functions, and instrument outputs are described. Each PCB circuit description is accompanied by a block diagram to illustrate the major circuits. Circuit names in these block diagrams also appear in the appropriate schematics in Section 5.

Section 2

Operation: This section familiarizes the user with basic equipment function. It identifies Controls, Indicators, and Connectors, and screen menu options. This section is not intended to instruct the operator in the clinical use of the instrument; such detailed instructions are provided in the separate *Operating Instructions* manual.

Section 3

Testing/Troubleshooting: This section contains the Performance Inspection Procedure (PIP)—sequential steps to follow when performing an operational check of the equipment. The instrument case does not need to be opened to perform the PIP. A PIP checklist is provided which can be duplicated and used during testing. The Test and Calibration Procedure (TCP) in this section describes calibration and more extensive instrument testing; it also includes a checklist. The Troubleshooting Aids includes additional tests and information to support troubleshooting.

Section 4

Service and Maintenance: This section provides Disassembly/Assembly Procedures for removing all major subassemblies. The procedures are referenced to numbered parts in the Final Assembly drawing in Section 5. This section includes instructions for inspecting, cleaning, maintaining, and repairing the instrument.

Section 5

Parts Lists/Schematics: This section contains a list of Supplies and Accessories, Illustrated Parts Lists, PCB Component Layouts, and Schematic Diagrams for all repairable assemblies.

Section 6

Component Reference Diagrams: An aid to troubleshooting, this section consists of Component Reference Diagrams for selected Integrated Circuits (ICs). The ICs in Section 6 are identified in the schematics in Section 5 with a large asterisk ✳.

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Description 1

Introduction

This section describes the general features, specifications, functions, and theory of operation of the LIFEPAK 10 defibrillator/monitor/pacemaker. The section is divided into three parts:

- Physical Description describes general features and lists specifications
- Functional Description briefly describes the circuitry at a functional block level
- Theory of Operation provides detailed circuit descriptions down to a major component level.

> ***Note:*** *Pushbuttons are indicated in* CAPITAL LETTERS *and displayed messages are indicated in* **BOLD CAPITAL LETTERS**.

Physical Description

The LIFEPAK 10 defibrillator/monitor/pacemaker is a portable instrument which offers dc defibrillation, electrocardiogram (ECG) monitoring, and optional noninvasive pacing. Any one of three rechargeable nickel-cadmium (Ni-Cd) batteries or an optional 120Vac, 220Vac, or 12Vdc Auxiliary Power Module supply power for the instrument.

The defibrillator delivers a controlled monophasic dc defibrillating pulse at any one of eight selectable energy levels ranging from 5 to 360 joules. Defibrillation pulses may be delivered through standard paddles, clip-on posterior or pediatric paddles, or optional FAST-PATCH disposable defibrillation/ECG electrodes. The defibrillator also offers synchronization for cardioversion whereby delivery of a defibrillation pulse is synchronized with detection of the QRS portion of an electrocardiogram.

Most of the defibrillator controls are located on the paddles. A rotary switch on the STERNUM paddle selects the energy level of the defibrillation pulse.

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Pressing the CHARGE pushbutton on the APEX paddle initiates the energy charging. Simultaneously pressing pushbuttons on both paddles initiates delivery of the pulse. Pressing the SYNC pushbutton on the instrument front panel initiates the synchronized mode.

While the instrument charges up to the selected energy level, a tone rising in pitch is emitted, an LED flashes next to the CHARGE pushbutton, and the increasing energy level shows on the front panel liquid crystal display (LCD) under the caption AVAILABLE ENERGY. After charging is completed, a single tone is emitted, the LED remains lit, and the selected energy level is displayed. If the energy is not discharged through the paddles within 60 seconds of charging, the energy automatically discharges internally.

The monitor captures ECG signals through a shielded three-lead cable, the defibrillator paddles, or the FAST-PATCH electrodes. The monitor displays the ECG waveforms on a no fade cathode ray tube (CRT) and can print the waveforms on a thermal strip chart recorder. The three-lead patient cable connects to the instrument through the ECG connector on the right side of the instrument.

Pushbuttons on the main control panel control the operation of the monitor, CRT and recorder. The operator may optimize QRS detection and display by increasing or decreasing the setting of ECG SIZE. The QRS VOL pushbutton allows the operator to adjust the volume of the audible beep emitted when a QRS is detected. The LEAD SELECT pushbutton allows selection of the lead for ECG input (Paddles or Leads I, II or III).

Pressing the RECORD pushbutton starts the recorder. In addition to printing the ECG waveform, the recorder also prints the time, date, ECG lead, ECG size, heart rate, SYNC (if activated), and optional pacing parameters. Pressing the CODE SUMMARY pushbutton causes the recorder to print a summary of critical events such as defibrillation or cardioversion, ECG monitoring, or pacing parameters.

The CRT displays the ECG waveform moving at 25mm/s from right to left. By pressing and holding the FREEZE pushbutton, the waveform "freezes" on the display for further examination. Pressing the CAL pushbutton superimposes a 1mV calibration signal on the CRT and recorder.

The optional noninvasive pacemaker allows output of a monophasic dc pacing current. The pacemaker control panel on the top of the instrument controls the pacing functions. The strength of the output current may be varied by increments of 5 or 20mA up to 200mA, and the rate may be varied between 40 and 170 beats per minute (bpm) by increments of 10bpm. The pacemaker operates "on demand." While in the pacing mode, the instrument monitors the ECG waveform from the patient and delivers the pacing current only when normal QRS activity is not detected. The pacing current is

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delivered through disposable pacing electrodes which are attached through the PACE connector on the left side of the instrument.

The AUX connector on the left side of the instrument provides output for transmission of modulated or unmodulated ECG data. It also allows connection of a 120Vac, 220Vac, or 12Vdc Auxiliary Power Module. The Power Module supplies operating power while also trickle-charging any of the batteries installed in the instrument. The Physio-Control Battery Support System must be used to properly maintain batteries as described on p. 4–3. An optional 12 lead adapter is available to allow acquisition of serial diagnostic-quality 12 lead ECG recordings.

The LIFEPAK 10 defibrillator/monitor/pacemaker is shown in Figure 1–1 . Specifications for the instrument are provided in Table 1–1.

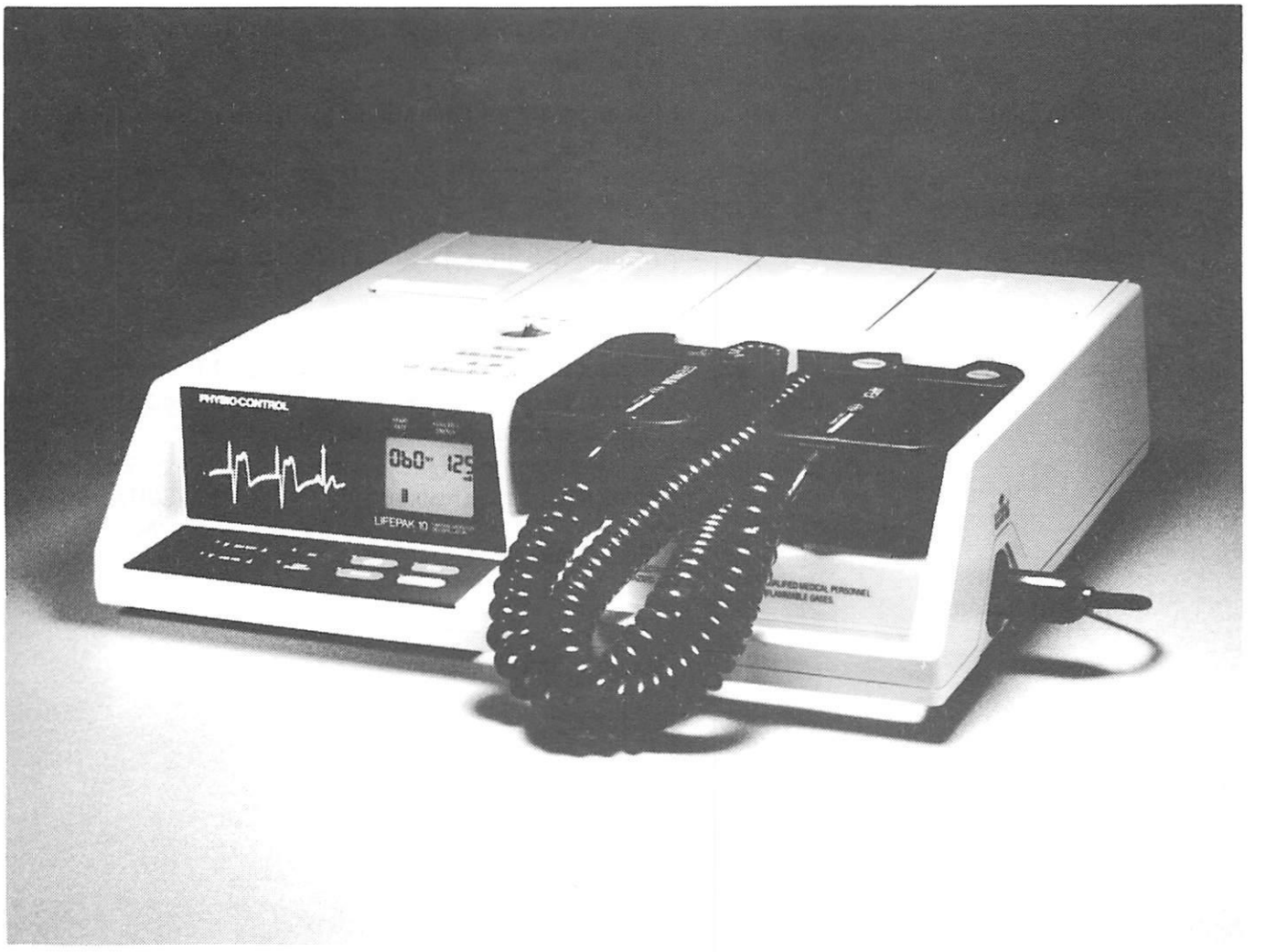

Figure 1–1 LIFEPAK 10 defibrillator/monitor/pacemaker

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Table 1–1 LIFEPAK 10 defibrillator/monitor/pacemaker General Specifications

	Specifications*
ECG Monitor	
ECG Lead Selection	Paddles, I, II, III
Input	Isolated ECG via QUIK-LOOK defibrillation paddles, FAST-PATCH electrodes, or 3-lead ECG cable
Electrical Isolation And Shielding	Input protected against high voltage defibrillator pulses and radio frequency (RF) interference per FDA Standard MDS-201-0004. The RF interference depends on distance from RF source, radio output power, radiating efficiency, vehicle environment, etc.
ECG Cable Length	3.96m (13ft) total length; 3.05m cable (10ft) with 0.91m leads (3ft)
Common Mode Rejection	Minimum 100dB with respect to chassis ground at 60Hz. 65dB minimum with respect to isolated ground
Cardioscope	
Display Size	72.5mm (2.85in) x 43.5mm (1.7in), no fade
Sweep Speed	25mm/s
Frequency Response	Monitor frequency response (domestic) 1.0 to 30Hz, -3dB Monitor frequency response (agency) 0.5 to 25Hz, -1.4dB Expanded frequency response (while Recorder in diagnostic mode) 0.05 to 30Hz, -3dB Paddles frequency response 2 to 20Hz, -3dB
Gain	17mm/1mV
Strip Chart Recorder	
Paper size	50mm x 30m (100ft)
Trace Center	±1.5mm
Paper Speed	25mm/s
Gain	10mm/1mV
ECG CAL Pulse	10 ±0.5mm
Noise	<2.0mm

(continued on next page)

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Table 1–1 LIFEPAK 10 defibrillator/monitor/pacemaker General Specifications

	Specifications*
Frequency Response	Monitor freq. resp. (domestic) 1.0 to 30Hz, -3dB Monitor freq. resp. (agency) 0.5 (-1.4dB) to 40 (-3dB) Hz Diagnostic freq. resp. 0.05 to 100Hz, -3dB Paddles freq. resp. 2 to 20Hz, -3dB CODE SUMMARY Domestic 1 to 30Hz Agency 0.5 to 40Hz
Annotation	Includes time, date, lead, gain, heart rate, defibrillator/ pacing parameters, sync mode
CODE SUMMARY Critical Event Record	Digitally stored record of critical ECG, device parameters
Status Display	
Heart Rate	Display rates from 20 to 295bpm
Available Energy	Defibrillator: quantity of energy charged and available (J) Pacemaker: pacing dosage selected (mA)
Diagnostic	Indicates recorder frequency response is 0.5 to 100Hz, -3dB
Monitor Controls	
ECG SIZE	Adjusts ECG gain
QRS VOLume	Adjusts loudness of QRS beeper
FREEZE	Momentarily halts the ECG trace on CRT
CODE SUMMARY	Activates CODE SUMMARY printout
RECORD	Activates strip chart Recorder; activates diagnostic mode if held for more than one second (when enabled)
CAL	Sends calibration pulse to monitor input
SYNC	Synchronizes defibrillator pulses to patient's QRS complex
LEAD SELECT	Selects ECG input: Paddles, I, II, III
ECG Output	1V/mV into 100Ω and 5000pF, multiplied by ECG SIZE selection (same frequency response as Recorder)
ECG Modulated Output	1400Hz ±2% center frequency, 1.0 ±0.1Vrms

(continued on next page)

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Table 1–1 LIFEPAK 10 defibrillator/monitor/pacemaker General Specifications

	Specifications*
Defibrillator	
Waveform	5ms monophasic pulse (Edmark) per AAMI specification
Energy Select	0J (disarm), 5J, 10J, 20J, 50J, 100J, 200J, 300J, 360J
Charge Time	Charge to 360J: <12sec above 0°C (32°F)
Energy Accuracy	±10% for 50Ω load at 10 to 40°C (50 to 104°F) ±15% for 50Ω load at -10 to 55°C (14 to 131°F)
Energy Meter Accuracy	±5%
Paddle Area	82cm^2 (adult) 16cm^2 (pediatric)
Cord Length	2.3m (7.5ft)
Synchronizer	Delivers energy discharge within 20ms of sync marker on cardioscope (triggers to patient-generated R wave)
Paddle Controls	
Charge	Charges defibrillator in preparation for shock delivery
Record	Activates strip chart Recorder
ENERGY SELECT (rotating dial)	Disarm (0J) to 360J
Shock	Dual energy discharge buttons (one on each paddle)
QUIK-PACE External Transchest Pacemaker (Optional)	
Output Rate	40 to 170bpm (user-selectable)
Rate Accuracy	±1.5% over entire range
Output Waveform	Monophasic, truncated, exponential current pulse with 20 ±5% droop measured at output current pulse ≥50mA peak at 20 ±5°C; pulse-width is 20 ±1ms measured at output current pulse ≥10mA
Output Current	0 to 200mA ±5% or 5mA (whichever is greater) at 700Ω, output variation <5% over the load range of 100 to 1500Ω
Refractory Period	Pacing Rates / Refractory Period 40-90 / 340ms ±3% 100 / 300ms ±3% 110-120 / 250ms ±3% 130-140 / 220ms ±3% 150-170 / 200ms ±3%

(continued on next page)

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Table 1–1 LIFEPAK 10 defibrillator/monitor/pacemaker General Specifications

	Specifications*
Environmental	
Temperature	Standby: 5 to 55°C (41 to 131°F) Operating: -10 to 55°C (14 to 131°F) after minimum two hours storage at standby temperature Storage (exclusive of batteries): -30 to 65°C (-22 to 149°F)
Humidity	0 to 95% (noncondensing), 0 to 34°C (32 to 93.2°F) 0 to 80% (noncondensing), 35 to 55°C (95 to 131°F)
Atmospheric Pressure	797 to 439mmHg (-570 to +15,000ft)
Shock (Drop)	With carrying case (soft case), passes drops of 43 inches from the handle (30 inches from case). This exceeds test levels per ECRI report, contract no. 223-77-5035, prepared for FDA (April 1979).
Vibration	
Helicopter Aircraft	MIL-STD-810D, Method 514.3 (category 6). Test levels per U.S. Army Aeromedical Research Lab Report No. 91-14, Section 2.6.3 (March 1991), (UH-1 helicopter, floor under co-pilot's seat).
Fixed-Wing, Turboprop Transport (take off and climb)	Test level of 0.0016 g^2/Hz, the maximum level per figure 32(31) of ECRI Report, contract no. 223-77-5035. Prepared for FDA (April 1979).
Caution: To help prevent component damage, do not mount the device near vibration sources such as engine struts and landing gear.	
Sealed Case	MIL-STD-108E and IEC 601-2-4
General	
Battery	Three Ni-Cd batteries, 12V, 1.0A-hour each. A new battery registering at least 100% capacity on the Battery Support System will minimally provide: - 45 minutes of monitoring, **or** - 30 minutes of pacing, **or** - 25 discharges at 360J **per battery**
Height	10.4cm (4in)
Width	40.6cm (16in)
Depth	37cm (14.6in)
Weight	9kg (20lbs) with all three batteries installed

*All specifications are referenced at 25°C unless otherwise stated.

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Functional Description

The overall function of the LIFEPAK 10 defibrillator/monitor/pacemaker is shown in Figure 1-2. The instrument includes eight mechanical assemblies. The Main Control Panel Assembly and Pacer Control Panel Assembly receive operator input. The Paddle Assembly and Relay Assembly help deliver defibrillation pulses. The remaining four mechanical assemblies, the Recorder Assembly, Status Display Module, CRT Assembly, and the CRT Printed Flex Circuit, display information to the operator. The CRT Printed Flex Circuit is not shown in Figure 1-2.

The instrument contains the four or five PCB assemblies below. The following paragraphs briefly explain each one in order:

- The System PCB Assembly
- The Anode Power Supply
- The Chart/Pacer PCB Assembly
- The optional MIEMSS (Maryland Institute of Emergency Medical Services Systems) Modulator PCB (not shown in Figure 1-2)
- The Energy Select PCB Assembly (not shown in Figure 1-2).

The System PCB Assembly controls all of the defibrillation and monitoring functions which include the operator interface, ECG signal processing, and defibrillation charging and delivery. As shown in Figure 1-2, the System PCB Assembly consists of seven subcircuits:

- Isolated Preamp Circuitry
- System Microcomputer Circuitry
- Defib Control/ECG Microcomputer Circuitry
- Defib Hybrids and Charger Circuitry
- No Fade Circuitry
- CRT Drive Circuitry
- Power Supply Circuitry

Two of the System PCB Assembly subcircuits employ 8-bit microcomputers with 16 kilobytes (KB) of internal programmable ROM (PROM): the System Microcomputer Circuitry, and the Defib Control/ECG Microcomputer Circuitry. Using instruction from the internal PROM, the System Microcomputer directs the overall function of the whole instrument as well as the interface with the Main Control Panel Assembly, the Status Display Module, and other instrument microcomputers. The Defib Control/ECG Microcomputer directs the defibrillation charging and delivery, as well as the ECG signal processing and information output. The other System PCB Assembly subcircuits are discussed below as they relate to other circuitry and are described in detail in Theory of Operation.

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The Chart/Pacer PCB Assembly controls the pacing and recorder functions. The design of the Chart/Pacer PCB Assembly is based on the same type of 8-bit microcomputer as used on the System PCB Assembly. The Chart/Pacer Microcomputer controls the interface with the Pacer Control Assembly as well as the output to the pacing electrodes and the Recorder Assembly.

The Anode Power Supply and the Energy Select PCB are non-repairable assemblies. The Anode Power Supply converts the +15Vdc and -15Vdc supplied by the Power Supply Circuitry on the System PCB Assembly to the +12kVdc needed to operate the CRT Assembly. The Energy Select PCB Assembly (located within the Sternum Paddle Assembly and not shown in Figure 1-2) allows the operator to select one of eight discrete energy levels for defibrillation discharge. The Defib Control/ECG Microcomputer Circuitry decodes the energy selection information on the System PCB Assembly. When the optional MIEMSS Modulator PCB Assembly is installed, a jack on the upper case provides simultaneous output of three ECG signals: two are frequency modulated and one is unmodulated.

Any one of three rechargeable 12V/1.0A-hour Ni-Cd batteries or an optional 120Vac, 220Vac, or 12Vdc Auxiliary Power Module provides power for the instrument. The Auxiliary Power Module, which can be connected at the AUX connector, supplies operating power while also trickle-charging any of the batteries installed in the instrument. The operator selects the power source by setting the five-position rotary POWER switch. The Power Supply Circuitry on the System PCB Assembly converts the +12Vdc input power to the dc voltage levels required. As previously mentioned, the Power Supply Circuitry also supplies +15Vdc and -15Vdc to the Anode Power Supply which supplies the +12kVdc to the CRT Assembly.

The ECG signals are captured from the patient through the three-lead ECG cable, the defibrillator paddles, or the FAST-PATCH electrodes. The Isolated Preamplifier Circuitry on the System PCB Assembly isolates, filters, and converts the ECG signal from analog to digital. The Defib Control/ECG Microcomputer analyzes the ECG signal for QRS detection. The signal is then passed to the No Fade Circuitry and CRT Drive Circuitry for display on the CRT Assembly and for output of a frequency-modulated or unmodulated ECG signal at the AUX connector.

The Defib Control/ECG Microcomputer oversees the output of the defibrillation pulses in response to operator input through the defibrillator paddles. When the operator presses the CHARGE pushbutton on the APEX Paddle Assembly, the Defib Control/ECG Microcomputer instructs the Defib Hybrids and Charger Circuitry to charge the High Voltage Capacitor to the level indicated by the ENERGY rotary switch on the STERNUM Paddle Assembly. When the operator simultaneously presses the discharge pushbuttons on both paddles, the Defib Control/ECG Microcomputer

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instructs the Defib Hybrids and Charger Circuitry to discharge the pulse through the paddles.

The Chart/Pacer Microcomputer directs the Pacer Output Control which controls the pacing current. The Chart/Pacer Microcomputer decodes the operator selections from the Pacer Control Panel and informs the Pacer Output Control at what rate and amplitude to deliver the pacing current pulse. The Chart/Pacer Microcomputer also passes the pacing output parameters to the System Microcomputer which drives the Status Display Module and displays the parameters to the operator. The Chart/Pacer PCB Assembly also includes an Isolated Power Supply and circuitry which limits the output of the pacing current pulse.

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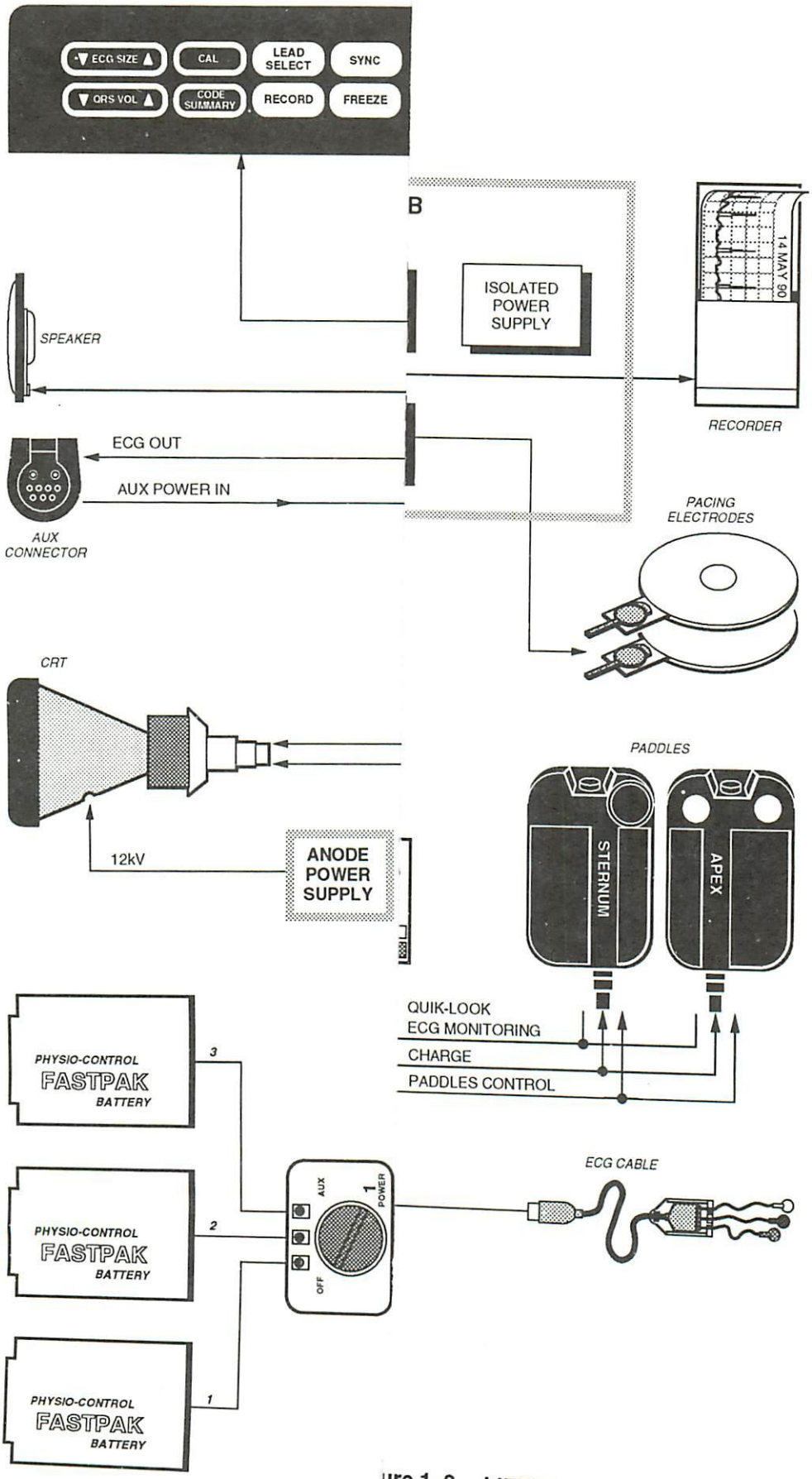

ure 1–2 LIFEPAK 10 defibrillator/monitor/pacemaker Functional Block Diagram

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Theory of Operation

The following paragraphs provide detailed circuit descriptions of the System PCB assembly, the Anode Power Supply, the Chart/Pacer PCB assembly, and the MIEMSS Modulator PCB assembly. Block diagrams of the PCB assemblies and many of the subcircuits are included in this section. In addition, schematic diagrams are provided in Section 5 which may be referred to while reading the descriptions.

System PCB Assembly

The System PCB Assembly contains the circuitry which controls all of the defibrillation and monitoring functions for the defibrillator/monitor. As shown in Figure 1–2 , the System PCB Assembly consists of seven subcircuits:

- Isolated Preamp Circuitry
- System Microcomputer Circuitry
- Defib Control/ECG Microcomputer Circuitry
- Defib Hybrids and Charger Circuitry
- No Fade Circuitry
- CRT Drive Circuitry
- Power Supply Circuitry

Isolated Preamp Circuitry

The Isolated Preamp Circuitry provides the initial ECG signal processing as well as leakage current isolation between the patient and the instrument. The ECG signal is obtained from the patient either through the ECG cable or through the defibrillation paddles using the QUIK-LOOK function. The preamp amplifies the ECG signal from the patient by 750, samples it at 600Hz, and converts the samples to precise pulse widths. The preamp then optically transmits the pulses across the Isolation Barrier to the Defib Control/ECG Microcomputer. As shown in Figure 1–3 , the Isolated Preamplifier Circuitry consists of a Selection Relay, a Protection Network, an ECG Leads Switching circuit, the Preamp Hybrid, and an Isolation Barrier.

Selection Relay. The Selection Relay K1 allows selection of ECG signal input from either the ECG patient cable or defibrillation paddles. Depending on instruction from the Defib Control/ECG Microcomputer, the Preamp Hybrid U41 asserts the Lo Control signal high (+5V) or low. When Lo Control is low, the coil amplifiers Q21 and Q19 saturate thereby energizing the coil in K1 and selecting paddles. When Lo Control is high, Q19 and Q21 are off so the coil is not energized, thereby selecting the ECG cable.

To ensure low relay contact resistance, U39, U42, and their associated components provide relay contact current during switching intervals. When the Lo Control signal transitions from a low to a high, this high-going edge is capacitively coupled through C128 and CR37 to U39 pin 3.

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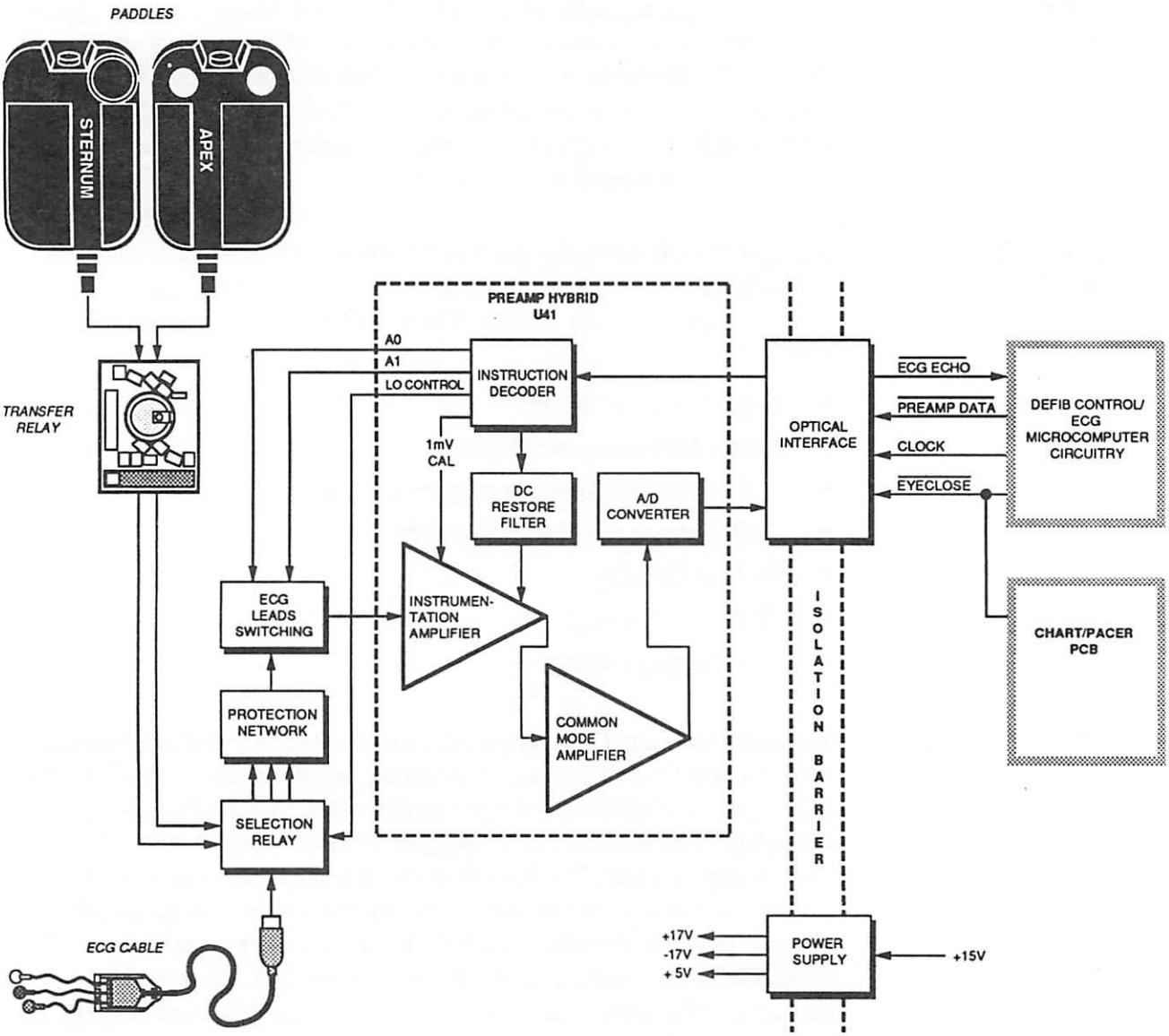

Figure 1–3 Isolated Preamp Circuitry

When Lo Control transitions from a high to a low, this low-going edge is inverted by U39 pin 2, and coupled through C129 and CR36 to U39 pin 3. Diodes CR36 and CR37 pass the positive transitions to U39 pin 3 while isolating the negative transitions, thereby ensuring that U39 pin 3 always receives a high-going signal.

The long time constant of capacitors C128 and C129 and resistors R196 through 198 allows the voltage present at U39 pin 3 to remain at logic high for 250ms to 2sec. This results in a low output from U39 pin 4 for 250ms to

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2sec whenever the relay switches. When U39 pin 4 is low, U42 pins 7 and 2 open, while switches U42 pins 10 and 15 close. Opening U42 pins 7 and 2 removes a grounded shunt on ac current sources R150 and R151. These current sources are high value 200kΩ resistors driven by a 20kHz ac current from the isolated power supply transformer, T2. Shunting this current prevents extraneous noise from entering the preamplifier circuit during normal operation.

Closing switches at U42 (pins 10 and 15) couples this ac current through the analog multiplexers, U40, U43, and to the K1 relay contacts. From there the current passes into the patient cable where it is shunted to ground by the cable capacitance. When this happens, the relay contacts momentarily switch about 80mA as the relay coil is energized or de-energized.

Protection Network. The Protection Network guards sensitive amplifier components within the Preamp Hybrid from damage during defibrillator discharges. The QUIK-LOOK contacts within the Transfer Relay provide additional isolation for the Apex and Sternum Paddle connections.

Primary protection is provided by gas-filled voltage surge protectors, VSP2 through VSP6. Secondary protection is provided by diode clamps to the supply rails. The Zener diode CR42 clamps the supply rails together. Third-level protection is provided by analog multiplexers U40 and U43. Relay K1 provides agency-mandated low voltage isolation between the ECG electrodes and the paddles.

ECG Leads Switching. The ECG Leads Switching circuit operates by multiplexing the Preamp Hybrid inputs (U41 pins 1 and 2) and reference drive output (U41 pin 5) to the appropriate ECG leads. Analog multiplexers U43 and U40 select the leads position by decoding the address appearing at A0 and A1 (U40/U43 pins 1 and 16). Refer to Figure 1–4 for the decoding information.

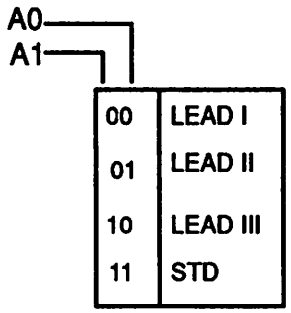

Figure 1–4 ECG Leads Decoding Information

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Preamp Hybrid. The Preamp Hybrid U41 consists of an instruction decoder, a dc restore filter, an anti-alias filter, an instrumentation amplifier, a common-mode amplifier, and an analog-to-digital (A/D) converter. These components are shown in Figure 1–3 . The inputs and outputs for U41 are described in Table 1–2.

Table 1–2 Preamp Hybrid (U41) Signal Descriptions

Pin	Pin Name	Signal Description
1	IN-M	Instrumentation amplifier inverting input.
2	IN-P	Instrumentation amplifier noninverting input.
3	Gain 2	Instrumentation amplifier gain-determining resistor connection.
4	Gain 1	Instrumentation amplifier gain-determining resistor connection.
5	CM Drive	Common-Mode Drive output. The inverted output of common-mode signals appear at the instrumentation amplifier inputs. This signal actively drives the ECG reference lead (the BLACK lead in LEADS-II, for example) to assist in nulling common-mode signals.
6	LS-M	Leads-Sensing Minus output.
7	LS-P	Leads-Sensing Plus output.
8	CT	High-Impedance connection to the dc restore timing capacitor (C134).
9	CM-A1	Common-Mode Adjustment connection.
10	CM-A2	Common-Mode Adjustment connection.
11	CM-A3	Common-Mode Adjustment connection. ***Note:*** *Common-Mode is preadjusted in the RN14 resistor network.*
12	Cal Drive	Calibration Drive output. A +5V reference level output applied to the second stage of the instrumentation amplifier through voltage divider resistors simulates a +1mV input applied to the instrumentation amplifier input.
13	A1	Address Select 1. One of two output address lines which determine the ECG leads input to analog multiplexers U40 and U43.
14	A0	Address Select 0. One of two output address lines which determine the ECG leads input to analog multiplexers U40 and U43.
15	+15V	(+) Power.

(continued on next page)

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Table 1–2 Preamp Hybrid (U41) Signal Descriptions

Pin	Pin Name	Signal Description
16	GND	Power common.
17	-15V	(-) Power.
18	+5V	+5V logic power.
19	$\overline{\text{Eyeclose}}$	Input. When asserted low, disconnects the output of the instrumentation amplifier from downstream devices to prevent charging the dc restore circuits and A/D circuits during a high level pacemaker pulse. Excessive pacemaker artifact results if this signal is not present.
20	Lo Control	Leads-Off Control output. In this instrument, this signal controls the Leads/Paddles selection relay.
21	Lo Carrier	Leads-Off Carrier output.
22	$\overline{\text{Preamp Data}}$	Serial control data input from the Defib Control/ECG Microcomputer.
23	Clock	Serial control clock input. Clocks the data in on the falling edge.
24	Trigger	Trigger input. Triggers the analog-to-pulse width conversion process on the falling edge.
25	$\overline{\text{ECG Echo}}$	Echo pulse output. The time interval between the falling edge of the Trigger pulse and the rising edge of the Echo pulse indicates the amplitude of the ECG input, amplified by the instrumentation amplifier.
26	(key)	An empty pin to establish orientation of the device.
27	Test 1	+5V reference input to the A/D conversion. The pulse width output is related to the ratio of this reference to the amplified ECG (ECG adjusted by R219).
28	Test 2	A test output of the A/D converter circuit. A ramp will be present on this pin whose amplitude is equal to the size of the amplified ECG and whose slope is related to the amplitude of the +5V reference on pin 27.
29	Test 3	The signal present on the upstream side of the $\overline{\text{Eyeclose}}$ switch.
30	Demod Drive	Demodulator Drive output.
31	I Amp Out	Instrumentation Amplifier output. The signal just on the downstream side of the $\overline{\text{Eyeclose}}$ switch.

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The Preamp Hybrid is controlled by a serial data stream from the Defib Control/ECG Microcomputer. The data is decoded by the instruction decoder which controls other circuit functions such as calibration and leads selection.

Because of interaction between software and the Preamp Hybrid, the Preamp Hybrid requires no external adjustments such as calibration of amplifier gain and offset. Also, the precision resistor network RN14 eliminates the need for common-mode adjustment.

The anti-alias filter rejects unwanted high frequency components of the incoming analog ECG signal. The Instrumentation Amplifier amplifies the signal. The dc Restore Filter restores the ECG signal to center by nulling any dc offsets introduced when switching power sources or changing lead selections. The Common Mode Amplifier drives the signal to the average value of the ac common-mode voltage present at the ECG electrodes. The A/D converter converts the analog signal to a digital value which is presented to the Defib Control/ECG Microcomputer.

The Preamp Hybrid receives the $\overline{\text{Eyeclose}}$ signal from the Chart/Pacer Microcomputer during delivery of pacing pulses. This disconnects the Instrumentation Amplifier for 40ms to prevent the ECG signal from being distorted by detection of the pacing pulses.

Isolation Barrier. The purpose of the Isolation Barrier is to electrically isolate the patient (connected through the ECG cable or defibrillator paddles) from the rest of the instrument circuitry. The incoming ECG signals and outgoing data signals are optically transferred across the Isolation Barrier through opto-isolators U35 through U38. The relative timing of the Clock and Echo signals determines the ECG value. These signals are coupled with minimum transmission delay since delays translate to apparent dc offsets on the ECG signal.

The isolated power supply receives +15V from the main power supply and converts it to +5V, +17V and -17V. The pulse width modulator U30 drives the FET switches Q23 and Q24 which drive the power transformer T2. The transformer secondary provides 17Vac which is rectified to provide unregulated power to the Preamp Hybrid. The unregulated +17Vdc is regulated to +5.00Vdc by U33. This regulated voltage provides the reference for the A/D converter in the Preamp Hybrid.

System Microcomputer Circuitry

The System Microcomputer Circuitry monitors and directs all of the major circuit functions of the System PCB Assembly as well as the Chart/Pacer Microcomputer. The System Microcomputer Circuitry, illustrated in Figure 1–5 , consists of the System Microcomputer, A/D Converter, EEROM, Main Control Panel Interface, Chart/Pacer $\overline{\text{Reset}}$ Driver, Auxiliary Output Selector, and Speaker Driver. Each component is described below.

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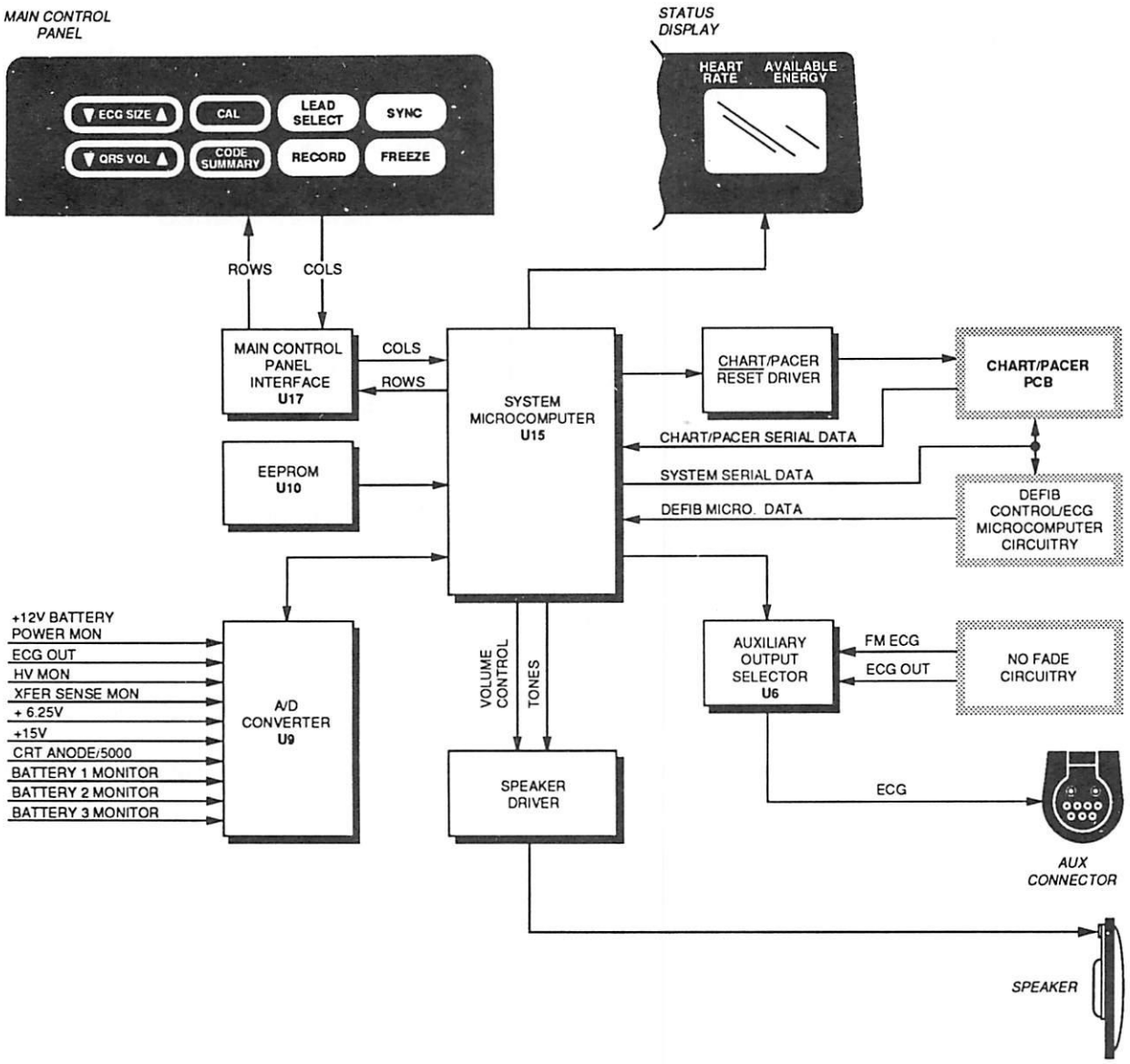

Figure 1–5 System Microcomputer Circuitry

System Microcomputer. The System Microcomputer U15 is an 8-bit microcomputer with 16K internal PROM and 256 bytes internal RAM. The PROM contains the operating software which allows U15 to communicate with and control other circuitry and the two other microcomputers in the instrument.

U15 uses the RAM for internal purposes such as storing operating modes and detecting a warm start condition. The combination of resistor R48 and capacitor C43 provides a time delay between the de-assertion of STBY and RESET on U15. When power is temporarily interrupted and then restored such as during power transients or when changing a battery, this time delay

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allows the RAM to maintain the operating modes selected. This allows the instrument to resume operation without performing the normal cold start initialization routines.

The System Microcomputer decodes operator input from the Main Control Panel and issues appropriate commands to the other components and circuits. It passes ECG operation instructions to the Defib Control/ECG Microcomputer and passes recorder instructions to the Chart/Pacer Microcomputer.

Critical instrument functions are monitored by the System Microcomputer. The Microcomputer either supplies warning information to the operator or, if a condition becomes potentially hazardous to the user, inhibits the instrument function until the condition is corrected. For example, if the Chart/Pacer PCB Assembly detects an out-of-tolerance pacing pulse, it reports the condition to the System Microcomputer which signals the Chart/Pacer $\overline{\text{Reset}}$ Driver to reset the Chart/Pacer Microcomputer and disable the pacing power supply. If the Defib Control/ECG Microcomputer Circuitry reports an out-of-tolerance voltage level to the System Microcomputer through the A/D Converter, the System Microcomputer inhibits the charging circuitry.

The System Microcomputer measures the voltage of the high voltage capacitor which stores the defibrillation energy. The Microcomputer calculates the energy and outputs the value to the Status Display, independent of the energy selected.

The A/D Converter monitors the voltage level of each of the three installed batteries. When a battery is selected for use, the System Microcomputer causes the associated battery LED to flash if the battery voltage is low but not depleted, or to remain on continuously if the battery is depleted.

The Input/Output port assignments for the System Microcomputer are shown in Table 1–3. The Pin column refers to U15 pin numbers. The direction of data in relation to the port is indicated by arrows: "<" port is an input, and ">" port is an output. The symbol "x" means the port is currently unassigned. Refer to Figure 6–15 on page 6–10 for a functional diagram and pin configuration for U15.

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Table 1–3 System Microcomputer (U15) Signal Descriptions

Pin	Port*		Signal Description
50	10	<	COL 0 (Keyboard Columns)
49	11	<	COL 1
48	12	<	COL 2
47	13	<	COL3
	14	x	
45	15	<>	$\overline{\text{Record}}$ Command (from Paddles Control)
44	16	<	QRS
43	17	<	Power Age Data In (PADI)
	20	x	
	21	x	
11	22	<	LEADS WARNING (Connected to preamp)
12	23	<	CHART/PACER SERIAL DATA (Data supplied by the Chart/Pacer PCB)
13	24	>	SYSTEM SERIAL DATA (Data supplied to the Defib Control µC and the Chart/Pacer PCB)
	25	x	
15	26	>	ALARM TONE
	27	x	
58	30	>	Power Age Data Out (PAD O)
57	31	>	Battery 1 LED
56	32	>	Battery 2 LED
55	33	>	Battery 3 LED
54	34	>	Pace Enable
53	35	>	Row 0 Keyboard
52	36	>	Row 1 Keyboard
51	37	>	Row 2 Keyboard
41	40	<	DI (Data from EEROM)
40	41	>	CLK (Clock to EEROM)
39	42	>	CS (EEROM Chip Select)

(continued on next page)

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Table 1–3 System Microcomputer (U15) Signal Descriptions

Pin	Port*		Signal Description
38	43	>	Speaker Volume Select 0
37	44	>	Speaker Volume Select 1
36	45	>	Speaker Volume Select 2
35	46	<	DSCHG CMD (Discharge Command, isolated through resistor)
34	47	>	DO (Data Out to EEROM)
17	50	<>	600Hz $\overline{\text{INT}}$
18	51	>	Auxiliary Output Select 0
19	52	>	Auxiliary Output Select 1
20	53	>	Freeze
21	54	>	System $\overline{\text{Fault}}$ Indicator $\overline{\text{Drive}}$
22	55	>	CLK (Address Clock to A to D)
23	56	>	XFER ENAB
24	57	<	DEFIB MICROCOMPUTER DATA
25	60	<	DI (Serial Data from 10-bit A/D)
26	61	>	$\overline{\text{CS}}$ (Chip Select to 10-bit A/D)
27	62	>	Chart/Pacer PCB Reset
28	63	>	Watchdog Holdoff
29	64	>	Defib/ECG Microcomputer $\overline{\text{Reset}}$
30	65	>	CRT Test Wave
31	66	<	Pace Fault
32	67	>	ADD (Serial Address to 10-bit A/D)
63	70	>	DATA (Serial Data to Status Display)
62	71	>	CLK (Clock to Status Display)
61	72	>	Data Ready (Data Strobe to Status Display)
60	73	>	x
59	74	>	x

* < = input port
> = output port
x = port unassigned

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Main Control Panel Interface. The Main Control Panel Interface U17 is a buffer which provides keyboard information to the System Microcomputer. The keyboard is an x-y matrix of pushbutton contacts (defined in Table 3–10, page 3–42, Main Control Panel Keyboard Matrix). The software causes a voltage to be applied consecutively from Rows 0 through 2. At the same time, the software monitors the U17 outputs at Columns 0 through 3, thereby decoding pushbutton selections.

EEROM. The 256-bit Electrically Erasable ROM (EEROM) U10 contains configuration and calibration information that is used by the System Microcomputer during operation. The configuration information defines operating parameters such as power-on operating modes, type of frequency response, maximum pacing rate, AUX signal output, and display language. For instructions about how to reconfigure the instrument, refer to page 2–8, Options Mode Selection and Programming.

The calibration information consists of parameters which are entered to ensure the correct discharge level and output display of defibrillation pulses, as well as printhead intensity levels. For instructions about how to recalibrate the defibrillator/monitor, refer to Section 3.

The EEROM also contains a log of failure codes. These codes are recorded any time the System Microcomputer detects a failure, and they can be useful in isolating malfunctioning circuitry. For information about these codes, refer to Table 3–9, page 3–40, Status Display Panel Failure Codes.

A/D Converter. The A/D Converter U9 is a 10-bit converter which accommodates 11 multiplexed analog inputs. The A/D Converter is controlled by the System Microcomputer and provides serial data about the status of battery voltages, CRT anode voltage, defibrillation discharge, and the ECG output signal. Figure 6–3 on page 6–4 provides an illustration of the internal blocks of circuitry and pin-out assignments of U9. The port assignments for the eleven analog inputs are described in Table 1–4.

Speaker Driver. The Speaker Driver produces the various tones that inform the user about the operating modes or conditions requiring service which may occur during operation. The Speaker Driver consists of op amps U5B and U5D, transistors Q4 and Q5, and associated resistors and capacitors.

Signals from U15 pins 15, and 36 through 38 control the Speaker Driver output. A U15 timer outputs an ac logic-level tone at U15 pins 36 through 38. Depending on the tone required, these output bits are set to either low or high impedance. When they are low impedance, resistors R43, R85 and R88 set the signal amplitude. The signal is then ac-coupled into U5B through C42 to prevent dc components from biasing the speaker. Op amps U5B and U5D drive transistors Q4 and Q5 which supply the ac signal for the speaker.

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Table 1–4 A/D Converter (U9) Port Assignments

Pin	Port*		Signal Description
1	0	<	+12V battery power monitor signal
2	1	<	Not assigned
3	2	<	ECG OUT (ECG input signal)
4	3	<	HV MON (monitor signal from Defib Hybrids Circuitry)
5	4	<	XFER SENSE MON (defib discharge signal from Defib Hybrids Circuitry)
6	5	<	+6.25V (power monitor signal)
7	6	<	+15V (power monitor signal)
8	7	<	CRT ANODE/5000 (CRT anode power monitor signal from Anode Power Supply)
9	8	<	BATTERY 1 MONITOR signal
11	9	<	BATTERY 2 MONITOR signal
12	10	<	BATTERY 3 MONITOR signal

* < = input port

Auxiliary Output Selector. The Auxiliary Output Selector U6 is a four-channel analog multiplexer which controls the type of signal that is output through the AUX connector. Depending on the logic level of the signal presented by U15 at U6 pins 1 and 16, U6 outputs ECG OUT, FM ECG, QRS MARK or PAD O (Power Age Data Out). Refer to Figure 6–4, page 6–4, for a function table for U6.

Selection of the ECG Out option switches an amplified ECG signal to the Auxiliary Output Selector. The unmodulated ECG signal is amplified by 1000 so that a 1mV ECG input signal is output as 1V when the ECG SIZE is selected as x1. For example, when the ECG SIZE is selected as x2, a 1mV ECG input signal is output at 2V.

On the No Fade Circuitry (described later in this section), U18B both buffers and shifts the level of the ECG signal from the D/A Converter U25, and from op amp U26C. The resulting signal is offset by +2.5Vdc, allowing it to be safely sampled by the A/D converter U9 which handles 0 to +5V. Full-scale range is ±1V (1.5V to 3.5V). When U6 selects this offset ECG signal, it is connected to the noninverting input of op amp U5C and amplified by two. U6 also connects a +5V reference voltage to the inverting input of U5C, cancelling the offset of the ECG signal and centering it around ground.

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The frequency-modulated (FM) ECG signal which is available at U6 can be transmitted to a remote location either by a radio wave transmitter or over telephone lines using an interface accessory. The QRS (SYNC) MARK can be used to send a sync pulse to an external monitor. The PAD O output is used during manufacturing testing only.

Defib Control/ECG Microcomputer Circuitry

The Defib Control/ECG Microcomputer Circuitry is primarily responsible for filtering the ECG signal, controlling the Preamp Hybrid, interfacing with operator selections on the defibrillator controls, and controlling the Defib Hybrids and Charger Circuitry. The Defib Control/ECG Microcomputer U20 is the same type of 8-bit microcomputer as the System Microcomputer. The 16KB internal PROM contains the operating software for the ECG signal processing and defibrillator control.

The ECG signal processing includes digital filtering, gain control, and QRS detection. Figure 1–6 illustrates the ECG signal path from the Isolated Preamp Circuitry through the Microcomputer to the output for the CRT and Recorder.

The Defib Control/ECG Microcomputer controls the output to the high voltage capacitor using a pulse-width-to-analog conversion technique. Depending on the defibrillation energy level selected through the paddles control, a precision pulse train is generated by timers within the Microcomputer. The duty cycle of this pulse train is proportional to a dc value which is extracted from the signal as the pulses move through the low-pass filter. The analog value generated from this process provides the voltage reference to a servo loop that controls the Charge Control Hybrid and the charging of the high voltage capacitor.

The Microcomputer receives serial data from the System Microcomputer which defines the operating modes, calibration constants, lead selection, etc. The Microcomputer sends serial data to the System Microcomputer which describes the status of the charge and discharge cycle as well as the results of tests performed on the preamp hardware, internal RAM and ROM, and the defibrillator output energy level.

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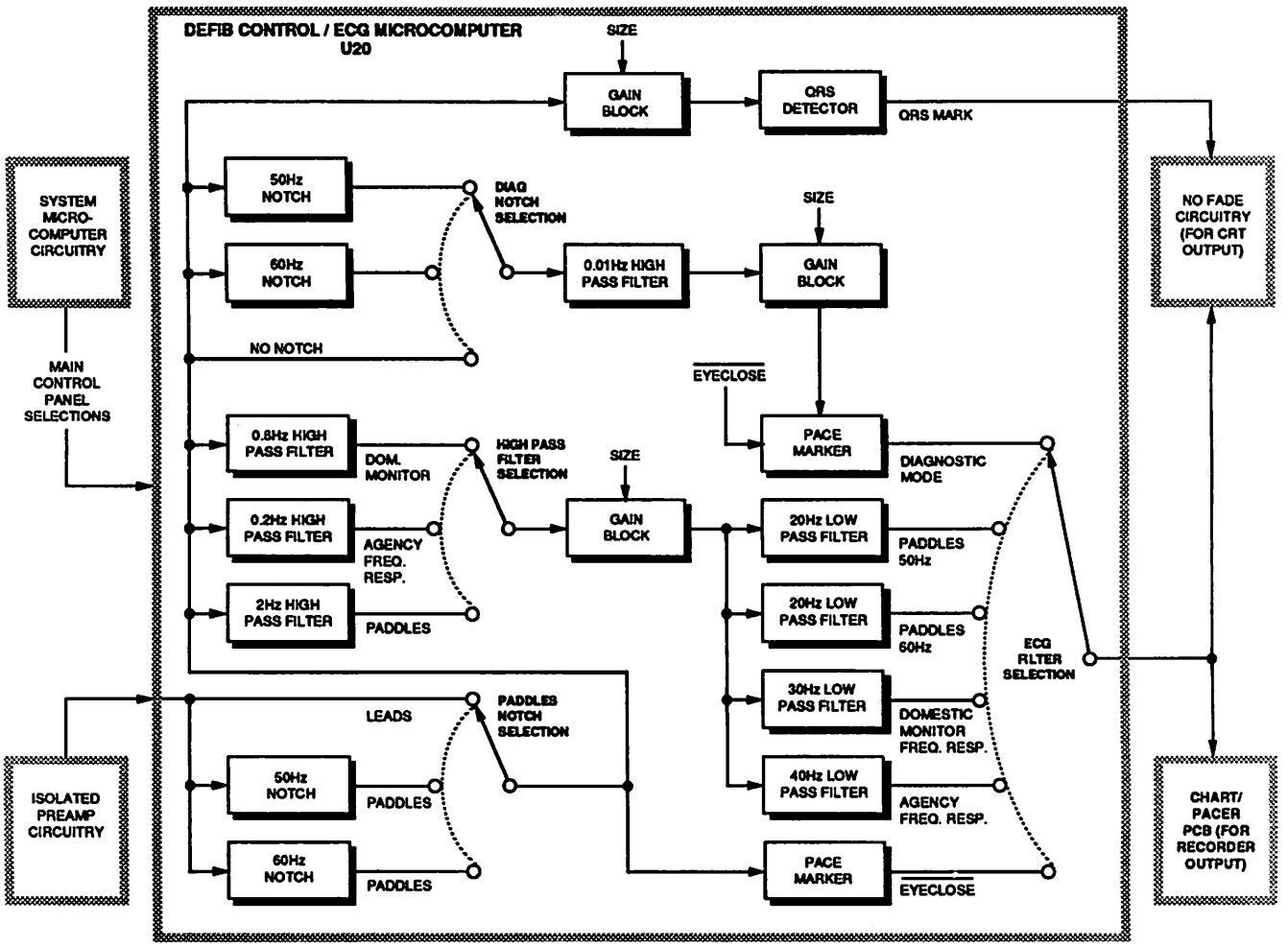

Figure 1–6 ECG Signal Path

The I/O port assignments for the Defib Control/ECG Microcomputer are shown in Table 1–5. The Pin column refers to U20 pin numbers. The direction of the data to a port is indicated by arrows: "<" port is an input, and ">" port is an output. The symbol "x" means the port is currently unassigned. Refer to Figure 6–15 on page 6–10 for a functional diagram and pin configuration for U20.

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Table 1–5 DEFIB Control/ECG Microcomputer (U20) Port Assignments

Pin	Port*		Signal Description
50	10	>	SPEED SEL (determines the time constant of the charge-control pulse width to dc low-pass filter)
49	11	>	XFER REQ (Transfer Request)
48	12	>	Defib Fault Indicator Drive
47	13	>	Charge Indicator Drive
46	14	>	Low Charge Rate Command
45	15	>	ACQ CHG (Acquire Charge)
44	16	>	High Energy Range
43	17	>	Defib serial data to System Microcomputer
9	20	<	ECG ECHO (ECG data from the preamp, encoded as a pulse-width)
10	21	>	PWM ENERGY (precision pulse train controlling capacitor voltage)
11	22	x	
12	23	<	SYSTEM DATA (Serial data from the System Microcomputer)
13	24	x	
14	25	>	600Hz Preamp Drive (trigger to preamp)
15	26	x	
16	27	x	
58	30	<	"0" Spare Input
57	31	<	"0" Spare Input
56	32	<	"0" Spare Input
55	33	<	Xfer Enable. D. watchdog (test pulse from System Microcomputer which monitors the integrity of the transfer switch drivers; also lets U20 know the System Microcomputer is functional)
54	34	<	CHG CMD from Paddles Control Pushbutton
53	35	<	Eyeclose (signal from the Chart/Pacer PCB informing U20 ECG processing that a pace pulse is present)
52	36	<	Energy Ready (signal from capacitor charger that the target voltage has been attained)
51	37	<	DSCHG CMD (Discharge Command)
41	40	>	ECG 0

(continued on next page)

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Table 1–5 DEFIB Control/ECG Microcomputer (U20) Port Assignments

Pin	Port*		Signal Description
40	41	>	ECG 1
39	42	>	ECG 2
38	43	>	ECG 3 ECG output to No Fade gate array
37	44	>	ECG 4
36	45	>	ECG 5
35	46	>	ECG 6
34	47	>	ECG 7
17	50	<>	600Hz INT
	51	x	
19	52	>	ESEL CS (Energy Select A/D C~S~)
	53	x	
	54	x	
22	55	>	ESEL CLK (Energy Select A/D Clock)
23	56	>	QRS (QRS pulse)
24	57	>	QRS Mark (QRS pulse, present in SYNC and Pacer mode)
25	60	<	ESEL DATA (Energy Select A/D Data)
26	61	>	DOWN-SAMPLE MODE
27	62	>	INTERNAL PACER DETECTED
28	63	>	VF DETECTED
	64	x	
	65	x	
	66	x	
	67	x	
	70	>	Spare Output
	71	>	Spare Output
61	72	>	Preamp Serial $\overline{\text{DATA}}$ (Serial control data to preamplifier)
	73	>	Spare Output
	74	>	Spare Output

* < = input port
> = output port
x = port unassigned

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Defib Hybrids and Charger Circuitry

The Defib Hybrids and Charger Circuitry controls the charging and discharging of the defibrillation pulses. The circuitry is illustrated in Figure 1–7 and consists of the Timing Control Hybrid, Charge Control Hybrid, Dump Relay Drive, Transformer T3, and associated components.

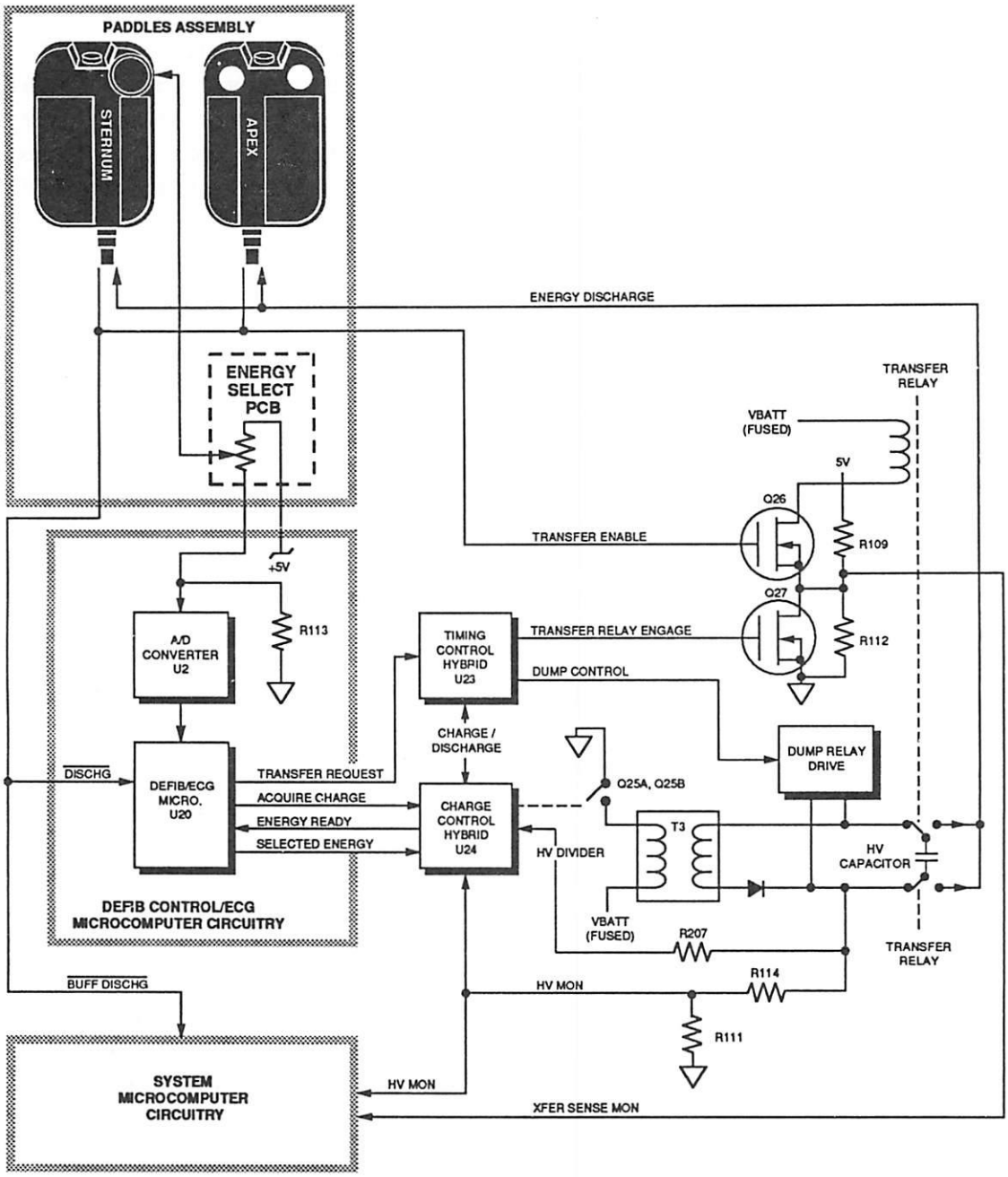

Figure 1–7 Defib Hybrids and Charger

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Timing Control Hybrid. The Timing Control Hybrid U23 controls the Transfer Relay Engage signal, the Dump Relay Drive, and the charge and discharge instructions for the Charge Control Hybrid, U24. U23 also monitors the +5V Interim Microcomputer Power Supply and the Transfer Request signal from the System Microcomputer.

The System Microcomputer U15 supplies a 300Hz pulse train to a watchdog circuit in U23 (pin 5). If the pulse train duty cycle falls below 25% or rises above 75%, the watchdog circuit detects the error and causes U23 to disable transfer, reset U15, and initiate internal discharge of the high voltage capacitor. U23 also causes the fault indicator to appear on the Status Display (because of the signal at U23 pin 8). The reset of U15 is asserted (U23 pin 12 is set low) for 200ms, then released for 50ms. This reset cycle continues until U15 responds by resuming normal operation.

U23 monitors the +5V power supply using a window comparator which is set at ±10%. If the voltage level is greater than +5.5V or less than +4.5V, U23 resets U15. This reset continues until the voltage level is restored to a value between +4.5V and +5.5V.

Voltage divider R99 and R100 divides the +12V battery voltage and then input the resulting voltage to U23 pin 9. If the battery voltage drops below +8V, the voltage on pin 9 drops to less than +2.5V. This drop causes U23 pin 6 to go high and U23 pin 7 to go low, signaling the power supply to shut down and U15 and U20 to enter the standby mode.

The Transfer Relay Engage is a one-shot 300ms pulse that turns on Q27 through U23 pin 13. Transistor Q26 must also be energized to activate the transfer relay. The Transfer Relay Engage is triggered by U20 pin 49 (Transfer Request) pulsing high.

Dump Relay Drive. The Dump Relay Drive, which consists of transistors Q14 and Q15, is closed during normal operation when U23 pin 20 (Dump) is high. While the high voltage capacitor is charging, the relay is open when U23 pin 20 is low and U23 pin 22 (Acquire Charge) is high. If the watchdog (WD Holdoff) or power monitor circuits inside U23 detect a fault while the capacitor is charging, the charge is terminated by U23 pin 24 (Charge Disable), and the Dump Relay Drive is closed. The Dump Relay Drive may also close as part of the normal capacitor charge process. This happens when the Charge Control Hybrid U24 requests a Dump Engage through U23 pin 21.

Charge Control Hybrid. The Charge Control Hybrid U24 controls the high voltage capacitor charger functions. The hybrid consists of energy select and comparison circuits, an overvoltage detect circuit, and part of a flyback charge oscillator circuit. It is also responsible for acquiring and maintaining

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the selected defibrillation energy charge. The energy control and overvoltage circuits use separate components and separate voltage references.

The energy select circuit receives a pulse-width-modulated signal output from U20 to U24 pin 9 that represents the selected energy. This signal chops a reference voltage which is then filtered and fed into a comparator string located inside U24. The comparator string receives voltages from the energy select circuit and the high voltage capacitor divider circuit (consisting of R207 and an internal resistor).

Except for external power components, the charge oscillator circuitry is internal to U24. The two states of the charge oscillation are the "on-time," where U24 pin 24 is high, and the "off-time," where U24 pin 24 is low.

The on-time is designed to increase as the battery voltage (+12VB) decreases. This allows the magnetic flux in T3 to build to a constant level regardless of the battery voltage, thus maintaining a relatively constant capacitor charge time even with varying battery voltages. The on-time period is approximately 20ms as long as the battery voltage equals +12V. During this time, U24 pin 24 (FET Drive) is high activating FETs Q25A and Q25B, and the magnetic field in T3 builds.

During the off-time period, U24 pin 24 is low, deactivating Q25A and Q25B. During this time T3 goes into flyback mode and delivers current through CR31 into the defibrillator storage capacitor. Flyback is monitored by U24 pin 26 (Feedback), which goes low during the flyback period due to the transformer secondary delivering current to the capacitor. When flyback is complete, U24 pin 26 returns to high and enables the next charge cycle to begin.

Before the next cycle begins, a slight delay is added by an internal RC circuit. This delay keeps U24 pin 26 from going high, and provides a small additional amount of off-time to make sure that transformer flyback is complete. If a fault is detected by U23, a low is sent from U23 pin 24 (Charge Disable) to hold U24 pin 26 low and disable the charger circuit.

Another function of the charger circuit described above is the "low charge rate" option. Low charge rate is selected when the U20 pin 46 output is high. Low charge rate is accomplished by placing the resistor in the internal on-time RC circuit in parallel with a second internal resistor. This resistance reduces on-time, lowers the peak currents into the transformer primary, and lowers the charge rate.

U24 also provides voltage references for its own internal functions as well as other circuit functions such as U23 pin 1 (+2.5V) and U24 pin 2 (+5.0V). For safety reasons, the voltage reference for the charger control functions is separate from the other system and charge monitoring functions.

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No Fade Circuitry

The No Fade circuit stores the digital ECG waveform in memory in order to display a no fade, low frequency waveform on the CRT (refer to Figure 1–8 , No Fade Circuitry block diagram). This circuitry provides the 3.4 second time delay needed for the recorder ECG waveform, and stores the QRS marks in memory. The No Fade circuit consists primarily of the No Fade Gate Array U22, RAM U27, dual D/A Converter U25, ECG Data Buffer U31, Voltage-to-Frequency Converter U11, Smoothing Filter U18A, and ECG Out Buffer U18B.

The CRT waveform appears to scroll across the display from right to left, with new data appearing on the right. During each 75Hz display cycle, the entire RAM buffer from the oldest to the newest value is displayed on the CRT. During each cycle, eight old values are sent to the Recorder, eight new values are stored in RAM, and the beginning address of ECG Data Buffer U31 is incrementally increased by 16.

The No Fade Gate Array U22 generates the 600Hz pulse used to interrupt the microcomputers and synchronize ECG processing and display. Prior to the interrupt, U22 pin 46 samples the QRS Mark from U20 pin 24 and stores it in U27 RAM in the even-address bytes. A new ECG value is read from U20, through the ECG Buffer U31 and is also stored in U27 in the odd address bytes. Both values are actually written twice, once to one half of U27, the "No Fade RAM," and again to the second half of U27, the "Delay RAM." Each half of RAM stores 2048 ECG samples and 2048 QRS mark samples. All the data in the No Fade RAM is sent to D/A Converter U25 to produce the analog signal that is amplified by the CRT vertical deflection amplifier. The oldest data in the RAM buffer is sent to the Recorder to be displayed as a delayed waveform (3.4 second delay), which is then overwritten with new ECG data.

Pressing the FREEZE pushbutton prevents new data from entering the No Fade RAM buffer and halts the display on the CRT. New data continues to be stored into the Delay RAM buffer. The recorder waveform data is now taken from the Delay RAM buffer so that no change appears on the delayed recorder ECG. When the FREEZE pushbutton is released, recorder data is once again taken from the No Fade RAM buffer so that the section shown frozen on the CRT is recorded on paper before the normal waveform resumes.

Voltage-to-Frequency Converter. U11 is a Voltage-to-Frequency Converter which produces a pulse train at output pin 3 at a frequency (1400Hz) proportional to its input voltage at pin 7. This pulse train drives a toggle flip-flop U7A and produces a symmetrical square wave frequency output of 2800 ±200Hz.

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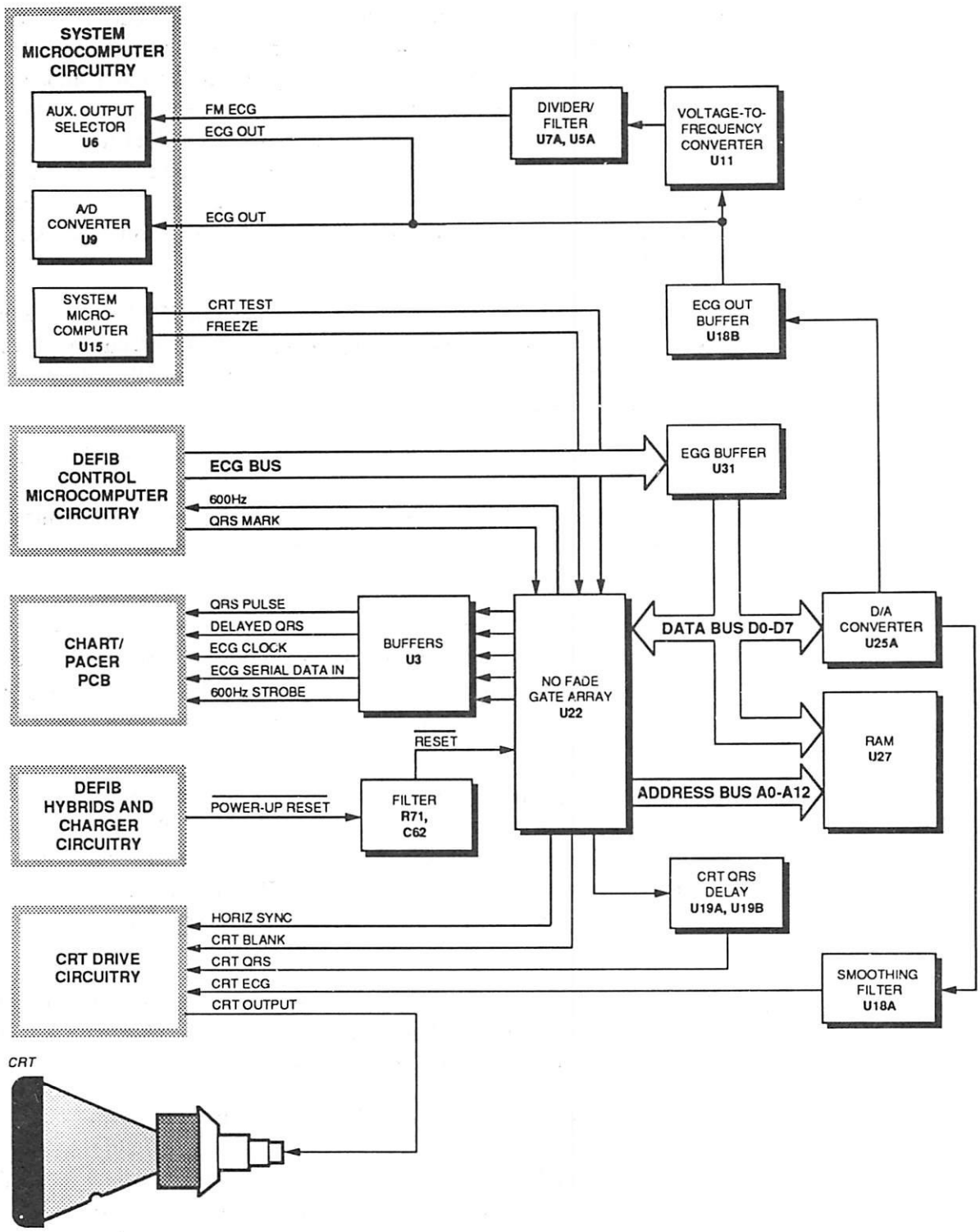

Figure 1–8 No Fade Circuitry

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Op amp U5A converts the square wave output of U7A to a sine wave for output to the Auxiliary Output Selector. The frequency-encoded ECG from U7A is a digital square wave between 0 and +5V. The frequency output desired is a sine wave with a 1Vrms amplitude, symmetrical in relation to ground. The amplitude, dc level, and square-to-sine wave conversion is performed by a low-pass active filter made up of U5A and related components, followed by a dc-rejecting RC network, R39 and C35. C35 and R39 provide rejection of any dc levels on FM ECG and center the output around ground. R41 prevents crossover distortion by increasing the bias current from U5A pin 1 to ground.

Smoothing Filter. The D/A Converter U25 can output 256 discrete analog levels corresponding to 256 possible digital inputs; however, this produces an ECG waveform with sharp voltage steps. The Smoothing Filter U18A removes these sharp steps.

New ECG data is sampled, stored by U22 every 1667ms (at 600Hz), and sent out to the CRT every 6ms. The ratio of frequencies in the CRT amplifiers to the ECG frequencies displayed on the CRT can be expressed as 1667ms/6ms = 277.833:1. Therefore a 10Hz sine wave input becomes a 2778Hz sine wave applied to the CRT.

The Smoothing Filter, op amp U18A, creates a time delay which may prevent alignment of the QRS mark with the QRS waveform. Therefore, one-shot U19B introduces a secondary delay to realign CRT QRS marks to the CRT ECG. U19A determines the time and size of the QRS marks on the CRT.

CRT Drive Circuitry

The CRT Drive Circuitry controls the CRT deflection, linearity, and brightness. The CRT Drive Circuitry shown in Figure 1–9 consists of Horizontal Deflection, Vertical Deflection, R Wave Intensification, Trace Brightness Drive, and Burn Protection. The CRT Drive Circuitry also receives input from the Anode Power Supply which is described later in this section.

Horizontal Deflection. Horizontal deflection of the CRT beam is performed by amplifier U34. This amplifier is designed to drive the CRT yoke with a slow sawtooth current and rapid retrace drive.

A sawtooth ramp waveform is created by a current mirror. When approximately +6.6V is applied to U34 pin 9, a constant current is produced through R186 and R187. This current is mirrored to C121 and C122 at U34 pin 16, and produces a voltage ramp. The amplitude of the ramp can be adjusted using potentiometer R187 to change the horizontal width.

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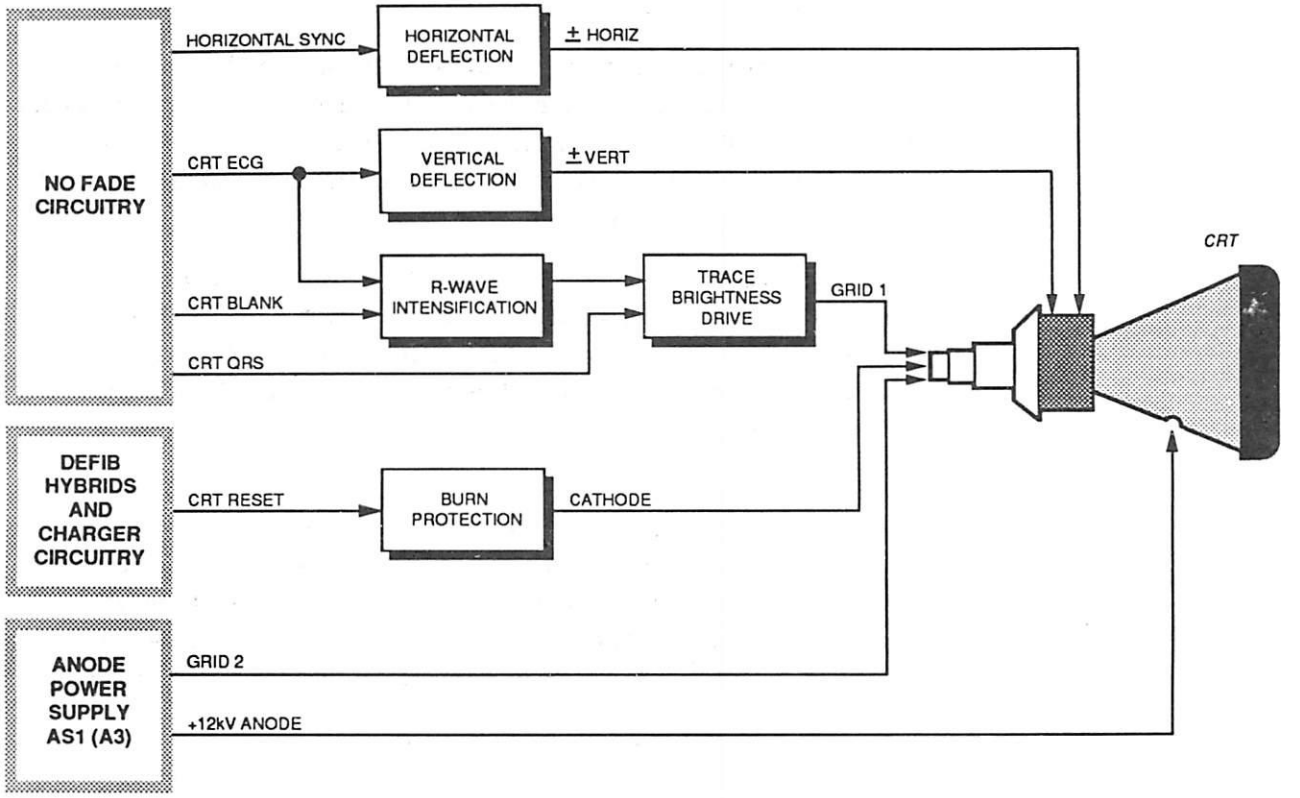

Figure 1–9 CRT Drive Circuitry

The signal at U34 pin 1 is a buffered version of the ramp that appears at U34 pin 16. The buffered ramp is fed back to the junction of C121 and C122 through R162 and potentiometer R164. These resistors provide linearity correction, so that horizontal beam deflection is undistorted.

The amplifier output signal from the U34 pin 6 drives the yoke with a negative-slope current ramp. The output current of the amplifier flows through R158. Voltage gain is determined by R154 and R159, and is compared at U34 pin 14 with the voltage present at pin 1. The steady voltage level at output U34 pin 6 depends on a divider made up of R140 plus R138 and R159 plus R158.

Power for U34 pin 6 is supplied by the +15V during the trace period, and by the flyback generator circuit during most of the flyback time. Frequency compensation of the output stage is provided at pin 15 by R160, C116, and C119.

Flyback (retrace) is initiated when the internal clock turns off the lower power output stage. During flyback, a voltage equal to approximately double the supply voltage is produced. This voltage is applied to the yoke by U34

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pin 6, allowing much shorter flyback time, and reducing power dissipation by approximately one-third.

During flyback time, the internal clock opens the loop of the amplifier. Interruption of current flow from the amplifier causes a high flyback voltage on the yoke. C101 connects to +15V at pin 3, pulling pin 7 up to nearly +30V. The current in the yoke is reduced, inverted, and increased until the amplifier begins to operate again.

When trace begins, the current starts to drop. This sudden change in the slope of the current is accompanied by a reduction in output voltage to less than +15V. This will return all flyback circuits to their pre-flyback conditions. During the trace time, U34 pin 3 grounds C101 and charges it to the supply voltage.

If no horizontal sync (Horiz Sync) signal is present at U34 pin 10, an internal oscillator generates the free-running frequency of the sawtooth yoke current. The oscillator uses an internal difference amplifier with positive feedback, using external components R165, R163 and C123. The free-running frequency of the oscillator can be adjusted with R165. The charge time of C123 is at least two orders of magnitude greater than the discharge time.

The Horiz Sync input pulse at U34 pin 10 lowers the level of the upper threshold of the oscillator and controls the frequency of the yoke current. The Horiz Sync pulse must occur during the last 30% of the free-running period of the oscillator to capture frequency control. The free-running frequency must be below the 75Hz of Horiz Sync and within the 14Hz frequency synchronization range. The U34 internal circuitry produces a +6.5V reference which may be monitored at U34 pin 8.

For better visibility, a high anode voltage of 12kV is used. Although this requires more deflection power than lower anode voltages, yoke inductances are as large as practical and beam speed requirements kept as low as possible. This allows very low deflection currents. The vertical deflection current, voltage, and speed are optimized for good efficiency.

Vertical Deflection. The Vertical Deflection circuitry converts the CRT ECG voltage signal into a current signal, creating a vertical deflection of the CRT beam proportional to the ECG signal. The CRT yokes produce a deflection of the electron beam roughly proportional to the current flowing in the yoke.

The Vertical Deflection circuitry consists of op amp U45, R133, R155, R156, R157, and associated components. The CRT ECG input voltage is divided by R156 and R157. Op amp U45 matches this voltage on the 1Ω resistor, R133. This forces a current through R133 that is proportional to the input voltage, and this current is also forced through the vertical deflection yoke.

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The yoke inductance is about 500mH which allows the peak yoke current to be quite small; less than 0.6A is required to fully deflect the CRT beam from center to the edge of the screen.

R155 provides damping for the vertical yoke. The 56Ω value of R155 prevents overshoot or ringing without limiting the bandwidth.

R Wave Intensification. The brightness of the CRT beam or trace depends on how fast the CRT electron beam is moving across the CRT phosphor. If the electron beam magnitude were constant, the steep R waves would appear very faint compared to the flat baseline between ECG QRS complexes. The R Wave Intensification circuitry, composed of op amps U12A and U12B, increases the brightness of the R wave so that the ECG trace intensity is uniform throughout the trace. The differentiator U12A and absolute value amp U12B detect whether the CRT beam speed is fast or slow, and brighten up the steep waveforms.

The gain of differentiator U12A increases for higher frequencies. This creates a signal to increase the CRT electron beam current at high frequency. The ratio of R53 to C50 determines the gain for frequencies below 23kHz; the output is equal to 126ms multiplied by the slope of the input.

U12A produces a voltage proportional to the vertical speed of the CRT electron beam. The voltage is negative for up-going deflection and positive for down-going deflection. Absolute-value circuit U12B rectifies the ECG QRS slope signal.

When the differentiator produces a negative voltage larger than the forward voltage of CR12, U12B pin 5, the noninverting input, is pulled low by CR12. U12B keeps its inverting input equal to the noninverting input. Since no current is flowing in R52, the output of U12B (pin 7) is also equal to the noninverting input, which is equal to the negative input voltage plus +0.7V (equivalent to the voltage of one diode drop).

When the differentiator U12A produces a positive voltage larger than the forward voltage of CR13, U12B acts as a noninverting amplifier with a gain of -1. The output of U12B pin 7 is equal to the negative of the positive input voltage minus one diode drop. The U12B output is modified by R220 which is adjusted during calibration.

Trace Brightness Drive. The Trace Brightness Drive circuitry controls variations in beam speed, imposes the QRS marks on the R wave, blanks the screen during retrace, compensates for variations between CRTs, and controls the operation of the Anode Power Supply. The Trace Brightness Drive consists of op amp U13 and transistors Q11 and Q12.

The CRT brightness is controlled by the voltage on Grid 1. Op amp U13 drives Grid 1 through its full range from cutoff (blank CRT) to full-bias

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(QRS marks). This is possible because the CRT Brightness Control resistor R27 (in the Anode Power Supply) adjusts the Grid 2 voltage and keeps the Grid 1 voltage within the +40V range of U13.

The cathode is biased at a nominal +15V. The normal operating range of U13 extends from -25V to +15V, providing a drive voltage (the voltage difference between Grid 1 and cathode) between -40V and 0V.

Op amp U13 is configured as a summing amp. It is an inverting amplifier with three inputs that are combined, inverted, and applied to CRT Grid 1 through R83 and R84.

The CRT is blanked during horizontal retrace. It is controlled by the digital signal CRT Blank from the No Fade Circuitry. CR15 blocks any signal during non-blank times, allowing the other voltage signals to control the CRT brightness. However, when the CRT Blank signal goes high, CR15 conducts. The CR15 gain is so high that it swamps out the other voltage signals, saturating U13 low to -25V, and blanks the CRT.

Between ECG complexes, the ECG trace is relatively flat and the CRT electron beam speed is quite slow. Baseline brightness is controlled through a voltage reference U44 which provides a temperature-stable +2.5V. This sets the output of U13 at about -17V when the CRT is not blanked and when the beam speed is slow. This allows a low beam current for baseline and low frequency signals.

Slope brightness is controlled by voltage signals from U12A and U12B which are proportional to the electron beam speed and are summed into U13. This increases the beam current during faster beam speeds to prevent steep ECG slopes from fading out. Because U13 is not quite fast enough to sum in the QRS marks (sync) signal, Q11 and Q12 are used to accomplish this.

A high current limit helps reduce excessively high beam currents at high ECG frequencies. The CRT electron beam current is not linearly proportional to Grid 1 voltage, but varies by the value of the voltage cubed. When Grid 1 voltage goes above +0.6V, CR10 reduces the gain of U13 by connecting R35 in parallel with R82.

Burn Protection. The Burn Protection circuitry protects the CRT from damage when the instrument is turned off. R56, R57, and Q10 provide a safe current path to ground for the CRT cathode current during normal operation. At power down, Q10 turns off when +5V power drops below a threshold. With no path to ground, the cathode current charges up C55 above +15V. However, raising the cathode voltage cuts back on cathode current, so a limit is reached where no cathode current flows. Transorb CR807 on the CRT PFC prevents the cathode voltage from going too high.

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Power Supply Circuitry

The Power Supply Circuitry shown in Figure 1–10 converts the +12V power supplied by one of the batteries or the Auxiliary Supply into the six dc voltages required to operate the instrument. These voltage levels and their functions are:

+18V	Recorder Printhead Supply, Pacer Power Supply
+15V	Deflection System, ECG Preamp, Anode Supply
+6.25V	CRT Heater
+5V	Microcomputer Power, Digital ICs
-15V	Deflection System, Anode Supply
-25V	CRT Brightness Control

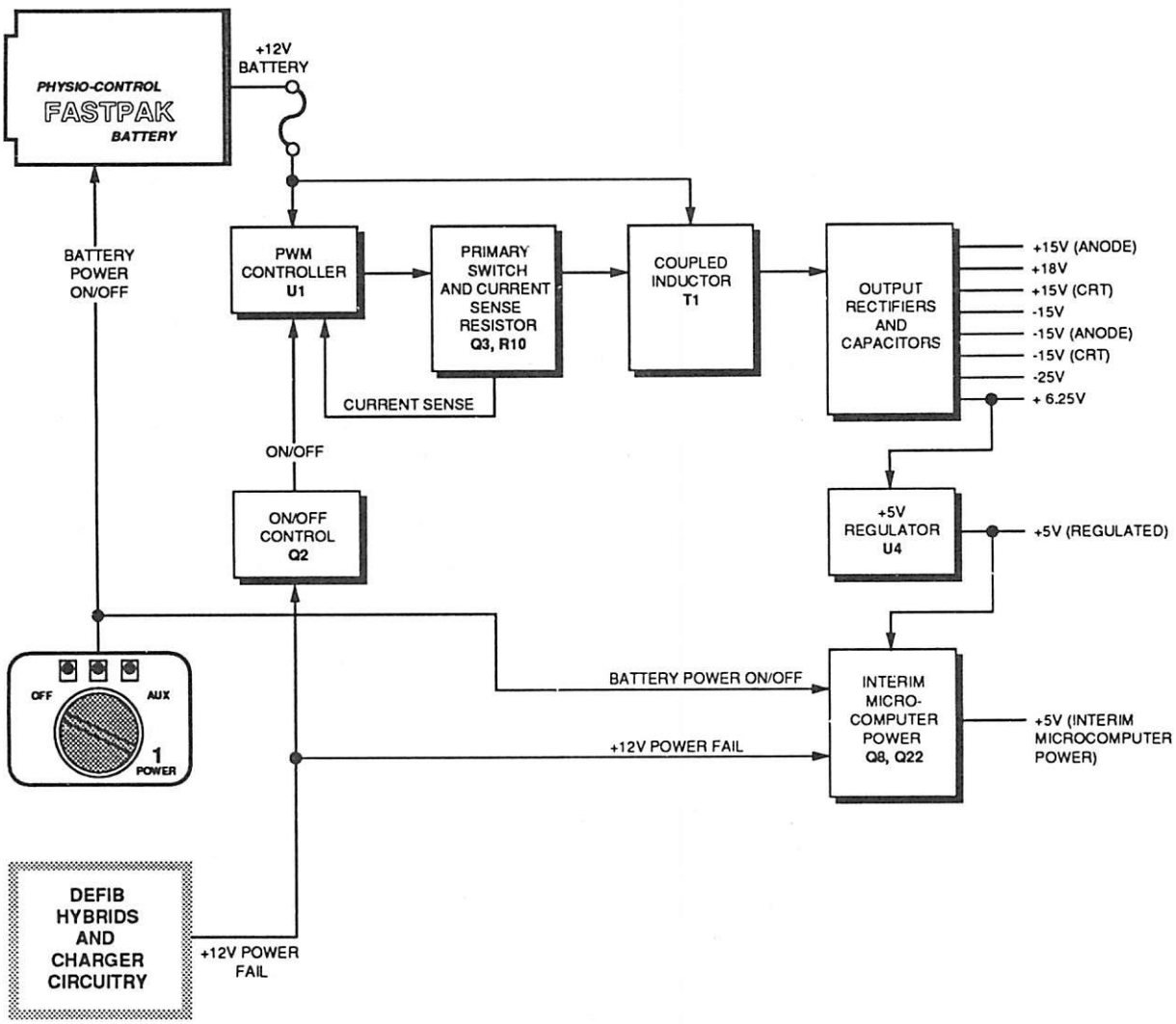

Figure 1–10 Power Supply Circuitry

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The Power Supply Circuitry consists of the following circuits: Pulse-Width Modulator (PWM) Controller, On/Off Control, Primary Switch and Current Sense Resistor, Coupled Inductor, Output Rectifiers and Capacitors, +5V Regulator, and Interim Microcomputer Power Supply.

PWM Controller. The power supply design is based on U1, a current-mode PWM controller. The controller provides good transient response and line regulation. The 100kHz operating frequency is set by R5 and C7. U1 pin 6 provides a 1A peak totem-pole drive.

On/Off Control. The On/Off Control is directed by the Defib Hybrids and Charger Circuit. A voltage comparator and a reference voltage monitor the selected battery voltage as signaled by the POWER rotary switch. As long as the battery voltage stays above +8V, the +12V Power Fail signal is low, and Q2 is on. When Q2 is on, power is applied to U1. If the battery voltage drops below +8V, the +12V Power Fail signal goes high turning off Q2, turning on Q1, and turning off U1.

Primary Switch and Current Sense Resistor. U1 pin 3 is the current sense input to the PWM controller. The primary current is sensed as the voltage developed across the parallel combination of R10 and R11. The parallel combination of R10/R11 (0.05Ω) sets the maximum primary current that can flow before U1 shuts off the primary switch. When the voltage across these resistors equals +1V, the primary switch is shut off.

The low-pass filter network made up by R6 and C5 filters any high frequency spikes that would shut down the U1 output prematurely. The output voltage feedback is taken from the +15V output. It is divided by R3 and R9. The noninverting input to the error amp is internally tied to a +2.5V band gap voltage reference. The inverting input is tied to the R3/R9 divider. Components C6 and R4 provide stabilization.

Coupled Inductor. The primary of the Coupled Inductor T1 is split into two halves. This reduces leakages that reduce efficiency. The secondaries are wound between the primary sections. Taps provide access to the output voltages.

Output Rectifiers and Capacitors. The output rectifiers, CR5 through CR8 are ultra fast recovery diodes. The ±15V outputs use high ripple current capacity polycarbonate capacitors C15 and C16 to handle the high frequency peak currents.

+5V Regulator. Regulated +5V is supplied to the instrument by U4, a low dropout linear regulator. It takes +6.25V and regulates it to +5V for the System and Chart/Pacer PCBs.

Interim Microcomputer Power Supply. Q22 and C20 provide +5V power to the two microcomputers on the System PCB during brief intervals (up to

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15 seconds) when power is removed. This allows enough time to change batteries without interrupting operation. During POWER OFF, Q8 is turned on by the charge left in the input capacitors C4 and C3 and discharges the microcomputer power supply.

Anode Power Supply

The Anode Power Supply AS1 is a high-voltage power supply which provides the 12kV for the CRT anode and the adjustable voltage for the CRT Grid 2. AS1 is the non-field-repairable PCB Assembly A3 which is mounted on the System PCB Assembly. The external connections of AS1 are shown in the schematic of the CRT Drive Circuitry (Figure 5–7, page 5–47), and a component diagram is provided in Figure 5–10, page 5–66.

The Anode Power Supply has three potentiometers: R25, R26 and R27. R27 is the CRT Brightness Control and adjusts the Grid 2 voltage. The calibration procedure for R27 is provided on page 3–26, the TCP-CRT Brightness Adjustment. Resistor R25 (+2.4V Adjust) and R26 (+12KV Adjust) are adjusted as part of the TCP-Anode Power Supply Test and Calibration on page 3–32.

Chart/Pacer PCB Assembly

The Chart/Pacer PCB Assembly controls the external pacemaker functions and chart recorder operations. As shown in Figure 1–11 , the Chart/Pacer PCB Assembly consists of three major circuits: the Chart/Pacer Microcomputer Circuitry, the Isolated Power Supply, and the Current Output and Fault Detector Circuitry. For instruments which do not have the optional pacemaker installed, the Chart/Pacer PCB Assembly is replaced by the Chart PCB Assembly which consists of only the Chart/Pacer Microcomputer Circuitry.

The Chart/Pacer Microcomputer Circuitry receives instruction from the System Microcomputer Circuitry as well as operator input through the Pacer Control Panel. The Chart/Pacer Microcomputer Circuitry sends pacing output information to the System Microcomputer Circuitry which drives the Status Display.

The isolation barrier maintains patient protection by isolating the pacing output circuitry from the rest of the instrument. The Isolated Power Supply provides isolated power to the Current Output and Fault Detector Circuitry.

The Current Output and Fault Detector Circuitry monitors pacemaker operation, limits pulse rate and duration, and delivers current pulses at clinically safe levels. It also detects disconnection of the pacing pads. If the Current Output and Fault Detector Circuitry detects a failure, it sends a fault signal to the System Microcomputer which shuts down the pacemaker Isolated Power Supply and the pacing function.

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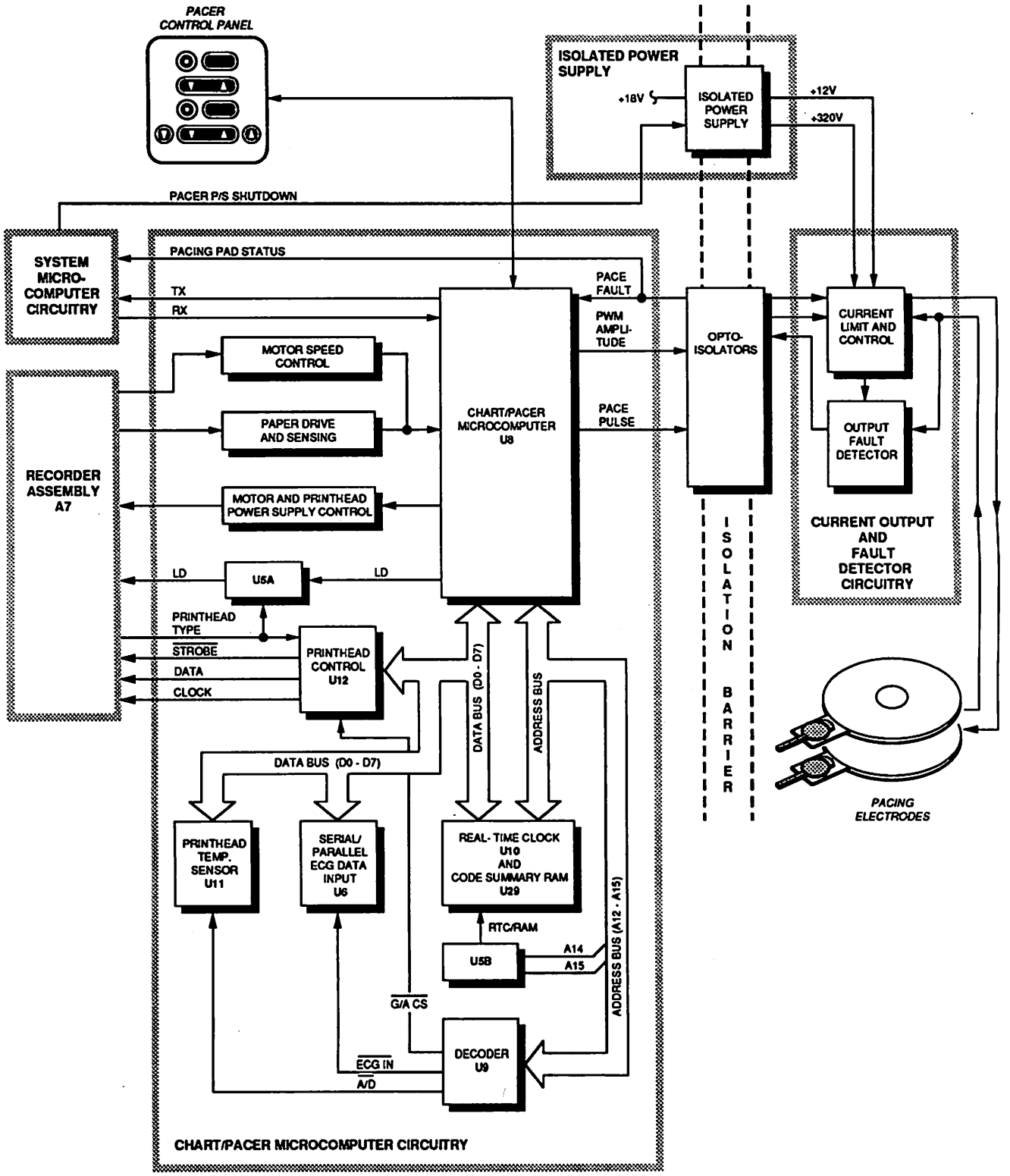

Figure 1–11 Chart/Pacer PCB Assembly

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Chart/Pacer Microcomputer Circuitry

The Chart/Pacer Microcomputer Circuitry controls the interface with the System Microcomputer Circuitry, the Pacer Control Panel, the pacing pulse output instructions, and the recorder output instructions. As shown in Figure 1–11 , the Chart/Pacer Microcomputer Circuitry consists of the Chart/Pacer Microcomputer, Printhead Control, Motor Speed Control, Paper Drive and Sensing, and Motor and Printhead Power Supply Control.

Chart/Pacer Microcomputer. The heart of the Chart/Pacer PCB is the Chart/Pacer Microcomputer U8. U8 is an 8-bit microcomputer with 16KB internal PROM and 256 bytes of RAM. The microcomputer operates in the expanded mode, which means it can access its internal 16KB of ROM and the 48KB of CODE SUMMARY RAM, as well as the three I/O locations (see Figure 1–12 for the memory map).

The port assignments for U8 are shown in Table 1–6. The Pin column refers to U8 pin numbers, and the Port column indicates the Port number. The direction of the data to a port is indicated by arrows: "<" port is an input; ">" port is an output.

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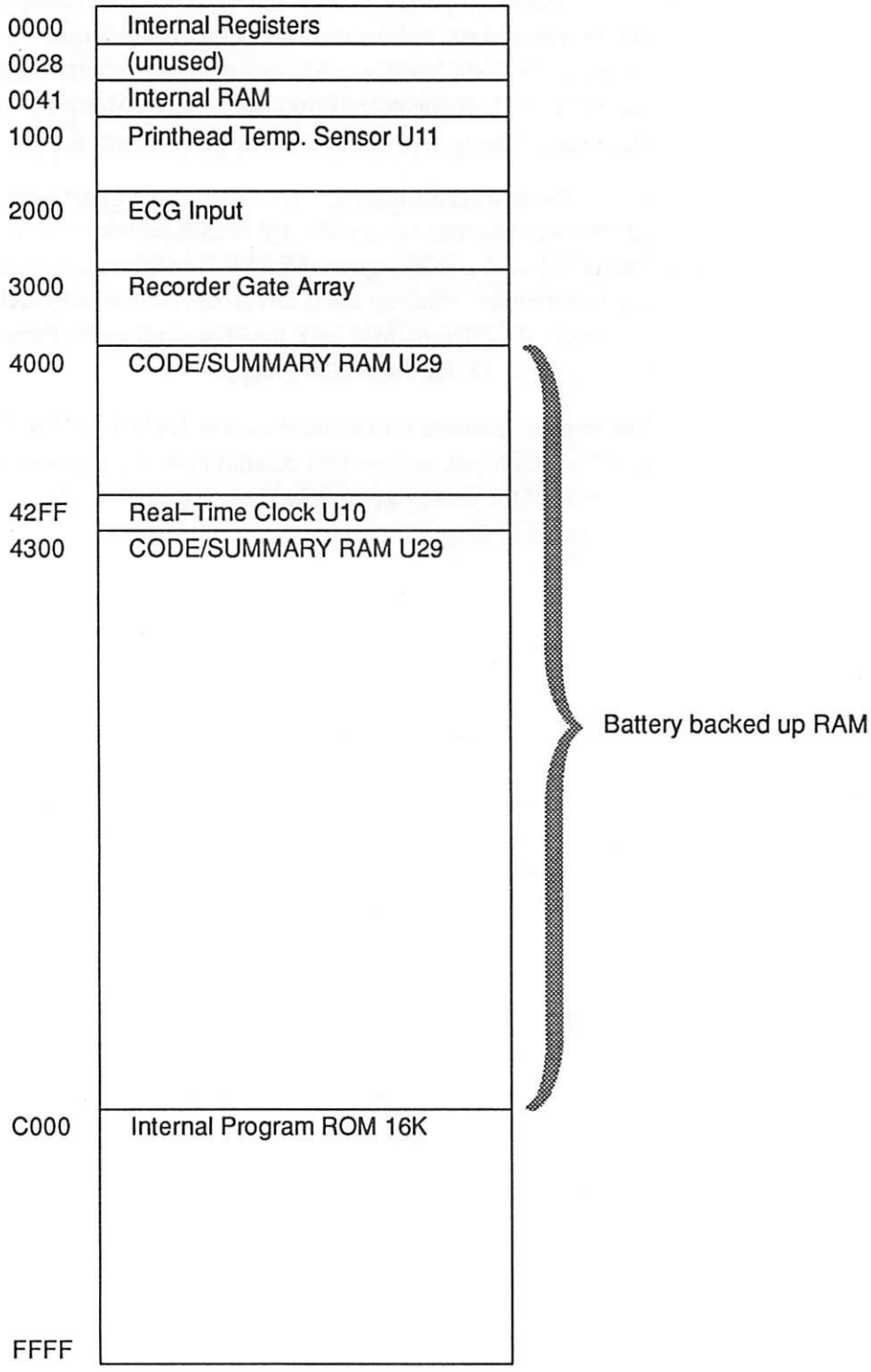

Figure 1–12 Chart/Pacer Microcomputer Memory Map

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Table 1–6 Chart/Pacer Microcomputer (U8) Signal Descriptions

Pin	Port*		Signal Description
50-43	10-17		A0-A7 (Input/Output)
9	20	>	START/STOP LED
10	21	>	PWM amplitude
11	22	>	Pacemaker LED
12	23	<	Rx from System PCB
13	24	>	Tx to System PCB
14	25	>	Strobe 1&2 to Recorder
15	26	>	Eye Close
16	27	>	Pace Pulse
58-51	30-37	<>	D0-D7
41-34	40-47	<>	A8-A15
17	50	<	IRQ1/600Hz strobe
18	51	<	Rate up
19	52	<	Rate down
20	53	<	Current up, 20mA increments
21	54	<	Current up, 5mA increments
22	55	<	Current down, 5mA increments
23	56	<	Current down, 20mA increments
24	57	<	Pacemaker START/STOP
25	60	<	Paper Drive
26	61	<	Motor and printhead voltage
27	62	<	Delay QRS Mark
28	63	<	Load Gate Array Strobe
29	64	<	Paper present, Motor Stall
30	65	<	Pacemaker on
31	66	<	QRS pulse
32	67	<	Pace fault
63	70	<>	RD
62	71	>	WR
61	72	<>	R/W (Input/Output)
60	73	<>	LIR
59	74	<>	BA

* < = input port, > = output port

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Printhead Control. To provide good print contrast on the chart recorder paper over a wide range of temperatures, the microcomputer monitors the printhead temperature through Therm 1 and 2 at U11 and adjusts the strobe width according to the formula:

$$\text{Strobe width} = \frac{\text{Printhead power}}{\text{energy per dot}}$$

Printhead power is actually determined when the Recorder is installed. At the factory, a three or four-digit resistance factor is printed on the recorder printhead label. During calibration, this resistance factor is entered through the Control Panel switches and stored in the System Microcomputer EEROM. Refer to page 3–31, TCP-Recorder Calibration, for detailed instructions for entering the printhead resistance.

Note that when the stored printhead resistance value is displayed after calibration, the displayed value may not exactly match the number entered during calibration. This is because the software maintains a table of eight discrete resistance factors. When a resistance factor is entered during calibration, the software stores the value from its table that is closest rather than the entered value. The stored values are shown in Table 1–7.

Table 1–7 Printhead Resistance Factors

Resistance Value Entered	Value Stored
<595	595
595 - 630	612
631 - 665	648
666 - 700	683
701 - 735	718
736 - 770	753
771 - 804	788
>805	805

The System Microcomputer uses this formula to compute printhead power:

$$\frac{(18V)^2}{xxx\Omega} = \text{Printhead Power}$$

After the correct resistance value is entered, the software computes the actual printhead resistance and determines the correct operating temperature of the printhead based on a table of stored values. The strobe pulse width input to the printhead is adjusted accordingly. Typically, the pulse width time lasts about 247 to 642ms to heat from 0 to 60°C (32 to 140°F).

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The Strobe signal is inverted in the gate array U12 before being input to the thermal printhead on the Recorder. This $\overline{\text{Strobe}}$ width pulse determines how long each dot should actually be turned on.

Motor Speed Control. The paper speed of the Recorder is regulated by circuitry that compares the load on the motor, or battery voltage to the paper drive motor, to a reference voltage. Depending on whether an adjustment is needed this circuit then varies the frequency of the voltage pulse that is delivered to the motor to maintain 25mm/s paper speed. Additional circuitry monitors the motor current and sends a signal to the microcomputer to turn off the motor if the motor current rises above a reference value, such as when stalling occurs. This protects the paper drive motor from burnout. The Motor Speed Control circuit consists of Q1, U1C, U1D, C11, C14 and associated components.

The paper drive motor operates by applying a variable-frequency to Q1 which outputs a pulsewidth to the motor. Q1 is controlled by U1C (refer to Figure 1–13 , Recorder Motor Speed Timing). The voltage on U1C pin 9 is compared to a calibrated preset voltage on pin 8. C14 charges to a value directly proportional to the speed of the paper drive motor. Under normal conditions the voltage on C14 must decay for several time periods before the voltage on U1C pin 9 is equal to the reference voltage on pin 8. When the two voltages are equal, the off period ends and Q1 turns on, supplying +18V to the paper drive motor for a period of time determined by C11. As the load on the paper drive increases, the time that Q1 is on increases allowing more voltage to the motor.

Motor loading or decreased voltage due to a low power condition has a reduced effect on paper speed because as the speed of the motor drops, the reverse bias (back EMF) also drops slightly. This shortens the charge time of C14, lessens the time it takes for the voltage on U1C pin 9 to equal the reference voltage on pin 8, and increases the pulse width of Q1.

Further circuitry protection is needed to protect the motor from burnout in the case of a complete motor stall. Motor stall can be caused by a paper jam, which forces current to build. As the current increases, the pulse width, and thus the voltage to the motor, increases until power to the motor is applied all the time.

To protect the motor from burnout under such circumstances, U1D pin 11 measures a current from the motor at R14, and compares that voltage to a reference at U1D pin 10. Voltage divider R15 and R16 provides a reference of about +1.2V. If the voltage on pin 11 exceeds that reference input, pin 13 goes high, sending a signal to U8. When U8 receives the signal, it outputs a low at U8 pin 26, which turns off Q2 and Q3 turning off the +18V to the paper drive motor and thermal printhead.

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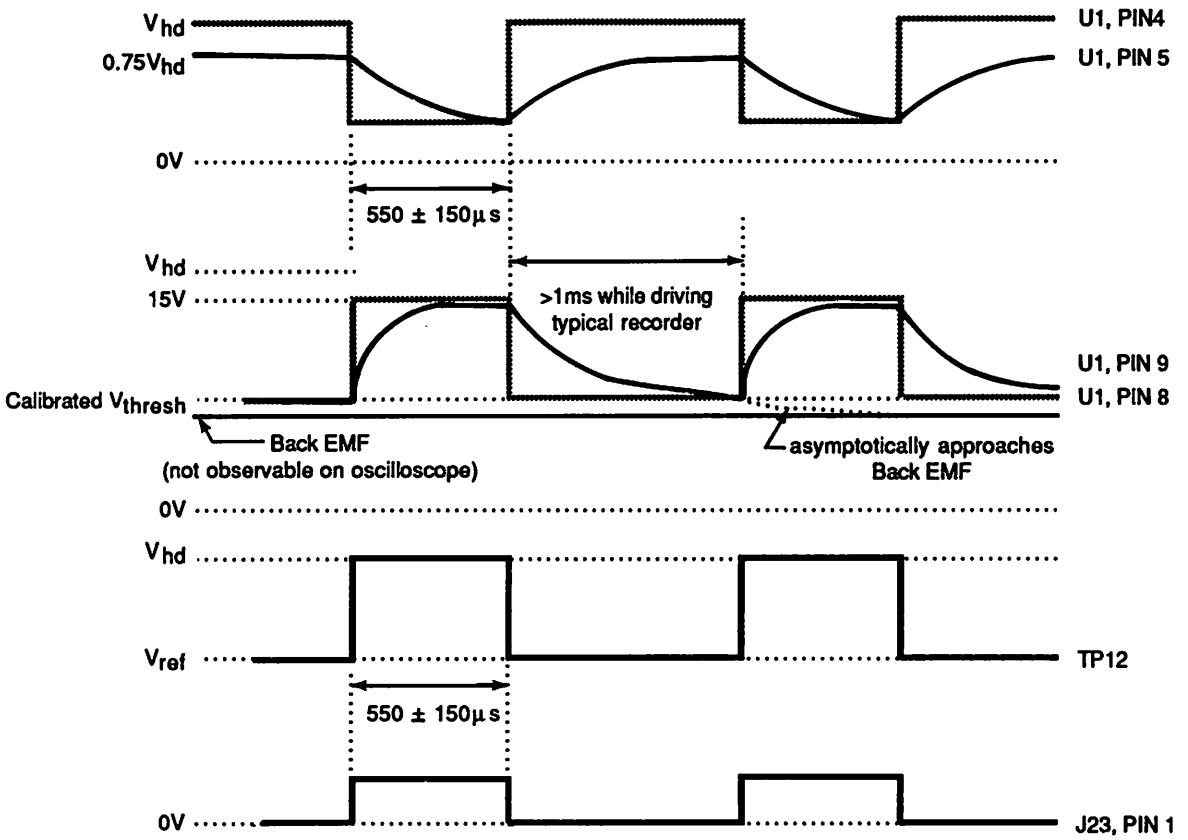

Figure 1–13 Recorder Motor Speed Timing

Paper Drive and Sensing. An infrared-emitting diode and phototransistor make up the reflective paper-out sensor. This sensor is built into the Recorder to alert U8 when the Recorder is out of paper or when the door is open.

U8 drives the infrared-emitting diode with a constant 37.5Hz square wave pulse through U3C. The pulse turns the diode on and off shining a light onto the paper. The light bounces off the paper, crosses the gap, and activates the sensor's phototransistor. If paper is present, the constant square wave signal is transmitted back to U8 pin 29 through U7A. The returning square wave signals the microcomputer that paper is present. If there is no paper present, a constant low is sent back to U8. Or, if the recorder door is open, the ambient light holds the phototransistor on all the time and the microcomputer sees a constant high from the Recorder.

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Motor and Printhead Power Supply Control. The Motor and Printhead Power Supply Control is designed to protect the recorder motor and printhead from excessive, prolonged voltages when the motor stalls. The circuit consists of Q2 and Q3.

If the motor should stall or if the paper is out, this information causes a low at U7A pin 1 and U8 pin 29. U8 then outputs a low from pin 26 which switches off power to transistors Q2 and Q3. This removes power from the recorder motor and thermal printhead.

Isolated Power Supply

The Isolated Power Supply provides patient isolation between the pacing circuitry and the rest of the instrument. This supply receives +18V from the System PCB Power Supply and provides isolated +12V and +320V to the Current Output and Fault Detector Circuitry. As shown in Figure 1–14 , the major components include the Transformer T1, Pulse Width Modulator U13, Opto-Isolators U15 and U18, and the Current Sense circuit.

Pulse Width Modulator. The primary component of the isolated power supply is a current-mode control pulse width modulator (PWM) U13. The current sense input of the PWM acts to limit the primary current. U13 drives Q5 at 100kHz with a maximum 50% duty cycle as long as the compensation pin, U13 pin 1, is allowed to go high. Shutdown occurs when the voltage across C32 reaches +16V, causing the output of comparator U21B to go low. This causes the phototransistor in Opto-Isolator U15 to be turned on which grounds compensation pin 1 of U13. When the voltage across C32 reaches +14.5V, U21B pin 2 goes high and allows U13 to operate. The result is a sawtooth waveform at C32 (TP18).

Current Sense. U21B receives its reference input from the +6.9V reference Zener device U20. This device prevents the supply from latching up at start-up. U19, a linear regulator, delivers a maximum of 100mA to the rest of the isolated circuitry. U26 provides a +5V reference that is used for pace pulse amplitude control and in the Current Output and Fault Detector Circuitry.

C53 acts as an energy storage capacitor for the pacing pulse. RV101 clamps the +320V and acts as a redundant hardware feature in the event the voltage rises above +390V.

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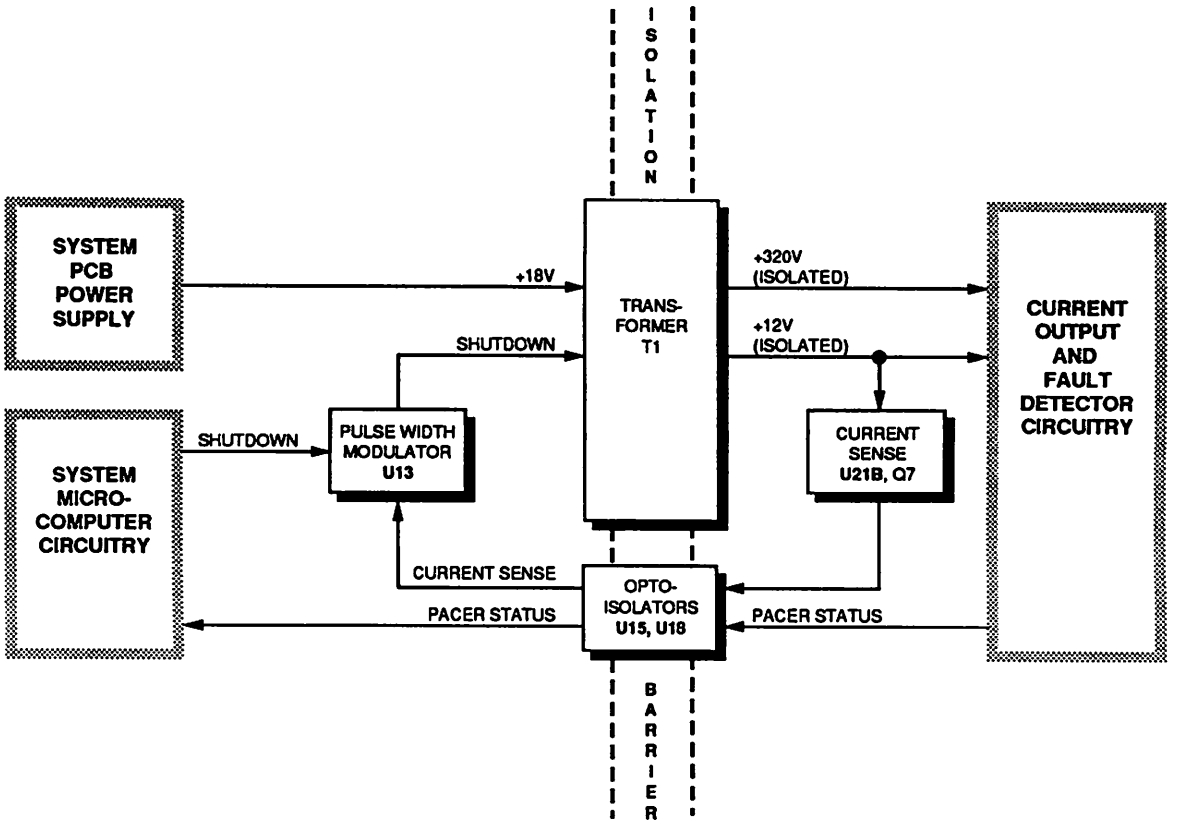

Figure 1–14 Isolated Power Supply

Current Output and Fault Detector Circuitry

The Current Output and Fault Detector Circuitry controls the output of the pacing pulses. It limits the pulse current and monitors the integrity of the pacing circuitry. As shown in Figure 1–15 , the Current Output and Fault Detector Circuitry consists of the Pace Current Control, Pulse Shaper, Voltage-Controlled Current Sink, Pulse Generator, Current Limit, Output Protection Network, Overcurrent Detect, Overrate Detect, Overwidth Detect, and Pacing Electrode Attachment Detector.

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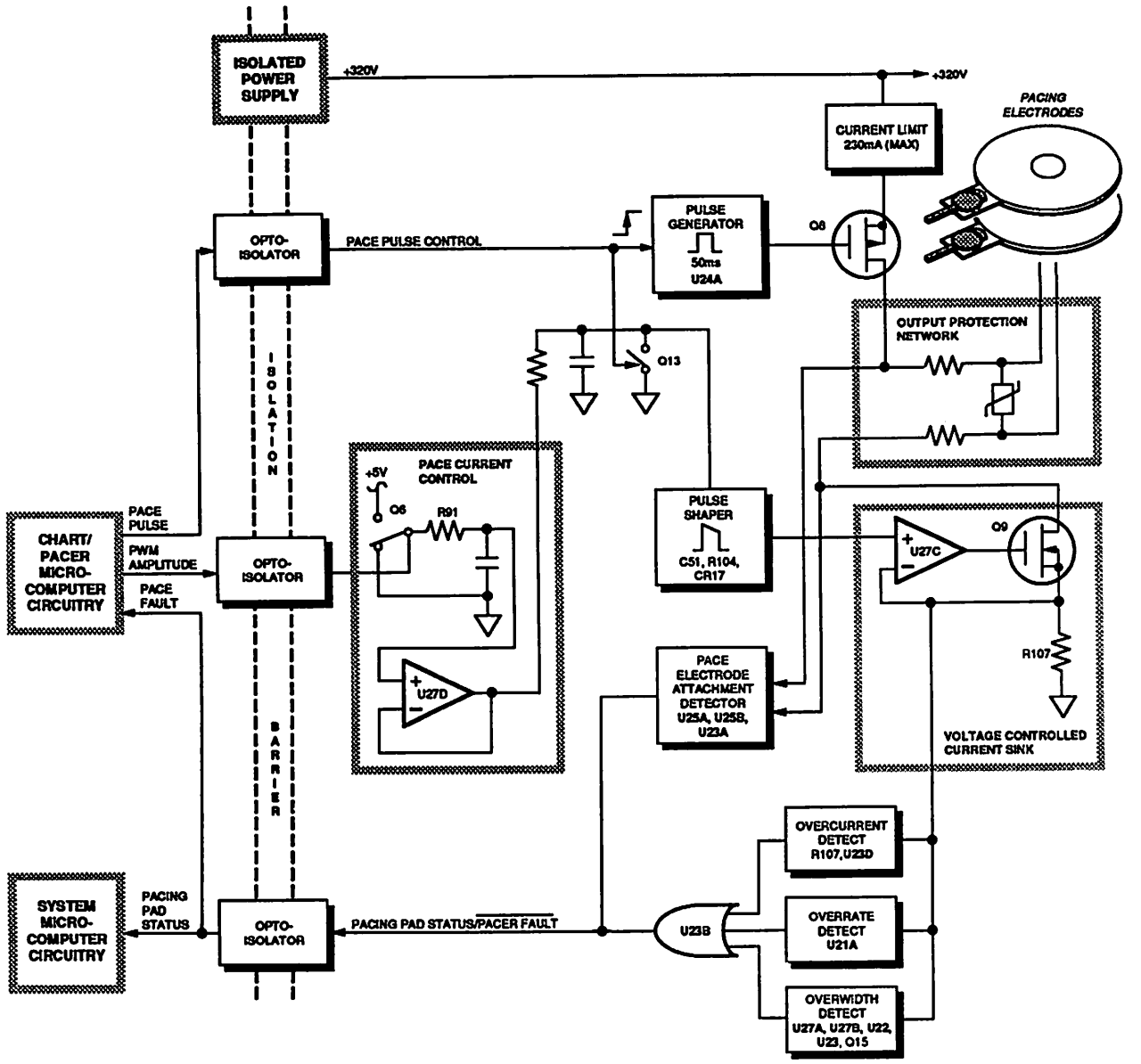

Figure 1–15 Current Output and Fault Detector Circuitry

Pace Current Control. The pace current amplitude is selected at the Pacer Control Panel. The selected energy level information is transferred from U8 through a pulse-width modulating (PWM) technique. When the internal LED of opto-isolator U17 is off, Q6 is turned on discharging C46 and C47 through R91. When the U17 LED is on, Q6 turns off and C46 and C47 charge through R91 and RN9. This charge and discharge cycle repeats under U8 control at a rate of 600Hz. The average voltage on C46 and C47 is proportional to the pace current selected by the operator.

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Pulse Shaper. The Pulse Shaper consists of Q8, Q11, Q13, U24A, U27D, CR17, and associated capacitors and resistors. The pacing pulse is delivered from U8 through Opto-Isolator U16. U16 turns off Q13 and trips one-shot U24A, which outputs a 50ms pulse defined by R87 and C38. The pulse turns on Q11 and Q8 and applies +320V to one side of the patient. The filtered output of U27D through R103 and C50 is applied to the pulse shaping circuit formed by C51 and R104. CR17 acts as a clamp to hold the input voltage of U27C to within -0.3V of ground. Q13 grounds the input of U27C when the LED in U16 is off and disables patient current delivery.

Voltage-Controlled Current Sink. The output of the Pulse Shaper circuit is the input to the Voltage-Controlled Current Sink formed by U27C, RN7, R107, and Q9. The Current Sink pulls down on the pace return side of the output to pull current through the patient. With an input of +4.4V, this circuit delivers 200mA to the patient.

Pulse Generator and Current Limit. The gated, current-limited 320V source, made up of Q10, Q11, R61, R62, and R63, can supply up to a maximum of 230mA. The gate of the current source is controlled by the one-shot, U24A. U24A has a maximum 50ms pulse width which prevents any pacing pulse greater than 50ms wide from being delivered to the patient. In addition, the Current Limit forces the pacing pulse amplitude to less than or equal to 230mA.

One-shot U24B prevents current from being delivered at a rate greater than 180bpm. It outputs a 300ms pulse on the falling edge of the delivered pace pulse. This output is applied to the clear input of U24A, thereby shutting off the current limited voltage source.

Output Protection Network. Varistor RV101 clamps the output voltage to a maximum of 390V.

Overcurrent Detect. The Overcurrent Detect circuit consists of U23B, U23D, and R107. Comparator U23D monitors the current source by measuring the current through the patient. If the voltage across R107 is greater than 5V, the delivered current is then more than 226mA. Since this 226mA is higher than the specified delivered current threshold, the comparator output goes low. This low signal transmits through U23B and the opto-isolator U18 to U8 where it is interpreted as a failure condition. The System Microcomputer then disables the Isolated Power Supply and the pacing output.

Overrate Detect. Comparator U21A monitors the voltage across C42 and determines whether the microcomputer has requested pace pulses at too high a rate. The output of U21A goes low if the pulse rate is too high. This causes a low at the output of U23B and alerts U8 to shut down the pacing output.

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Overwidth Detect. Comparator U23C detects when the duration of a pace pulse is too long. The presence of patient current is detected by U27B and comparator U27A. When patient current is present, current source U22 charges C48. If the voltage across C48 rises higher than about +5V, the pulse duration is detected to be too long. Comparator U23C output goes low causing U23B to go low and alert U8 to shut down the pacing output.

Pacing Electrode Attachment Detector. The Pacing Electrode Attachment Detector circuitry applies a low level ac current to the pacing output circuitry and monitors the resulting voltage developed across the patient. This voltage is measured to determine the continuity of the output circuitry. If the patient impedance is greater than 10kΩ the electrodes are considered detached. If the patient impedance is less than 5kΩ the electrodes are considered attached.

The external (patient) impedance is part of a series circuit that includes a 2kHz oscillator circuit made up of U21C, R82, R83, and C45. The output of this oscillator is ac-coupled through C41 to the resistor/patient network made up of R73, R75, and the patient resistance.

Differential amplifier U25A monitors and amplifies the difference in voltage across the patient. This differential voltage is applied to the input of a bandpass filter formed with U25B. The bandpass has a gain of 10 with the center frequency set at 2kHz, and is biased up to +6V by RN6.

When the output of U25B is greater than 1V peak-to-peak, comparator U23A applies a square wave to the gate of Q12. This oscillation is sent through opto-isolator U18 to the Chart/Pacer Microcomputer and is interpreted as an electrodes-off condition.

MIEMSS Modulator PCB

The LIFEPAK 10 defibrillator/monitor/pacemaker produces either standard ECG (1V/mV) or frequency-modulated ECG. The optional MIEMSS (Maryland Institute of Emergency Medical Services Systems) Modulator PCB produces both signals simultaneously for output to the auxiliary connector (1V/mV and MOD ECG OUT). A third output at the auxiliary connector is an additional frequency modulated ECG signal (MOD ECG SPKR) which can drive an external speaker. Figure 1–16 shows the functional blocks of the MIEMSS Modulator PCB circuit.

The circuit uses the existing ECG signal from the System PCB to create the three ECG signal outputs at the auxiliary connector. To connect to the System PCB, op amp U18 on the System PCB is removed and is replaced by a connector from the MIEMSS PCB. The same functions that U18 performed as part of the System PCB op amp U4 performs on the MIEMSS PCB. U4A is the same as U18A; U4B is the same as U18B.

The ECG OUT signal from U4B is the source for all three ECG output signals. This signal (also used by A/D converter U9 on the System PCB,

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Figure 1–5 , page 1–18) has an offset of +2.5V which is canceled by op amp U1A.

The gain of both the modulated and unmodulated ECG signals is set to -2 by op amp U1B. This allows the signal that is going to be modulated to meet the input requirements of the modulator IC, U2. The signal that will remain unmodulated passes to op amp U1C; U1C fixes the gain at -1 and inverts the signal for output to the auxiliary connector as 1V/mV.

Modulator U2 is a voltage-controlled oscillator which is biased by a number of resistors and capacitors. Resistors R4 and R5 add offset to the input of U2. Potentiometer R6 adjusts the frequency of the oscillator to 1400 ±28Hz. C3 is a timing capacitor, and C2, C5, and C9 through 11 provide filtering for the +15V line. The output of U2 is a triangle waveform.

Audio amplifier U3 boosts the ECG signal gain to 50 before it passes to the auxiliary connector. The gain is varied by adjusting potentiometer R9.

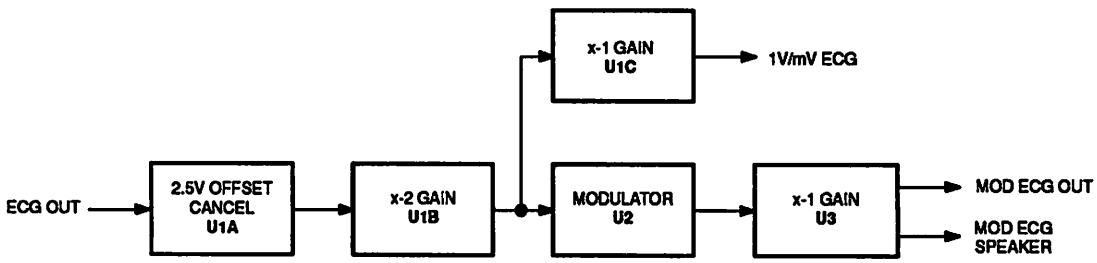

Figure 1–16 MIEMSS Modulator PCB

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Operation 2

Introduction

This section provides information about the basic operation of the LIFEPAK 10 defibrillator/monitor/pacemaker. It is not intended to instruct an operator in the clinical use of the instrument. For clinical use, refer to the separate *Operating Instructions* booklet. This section includes information about the following:

- Controls and Indicators
- Status Display Indicators and Messages
- Options Mode Selection and Programming
- CODE SUMMARY description
- Setting the Real-Time Clock.

Controls and Indicators

Figure 2-1 and Table 2-1 provide information about the external features of the LIFEPAK 10 defibrillator/monitor/pacemaker including controls, indicators, and connectors.

> ***Note:*** *Pushbuttons are indicated in* CAPITAL LETTERS *and displayed messages are indicated in* **BOLD CAPITAL LETTERS.**

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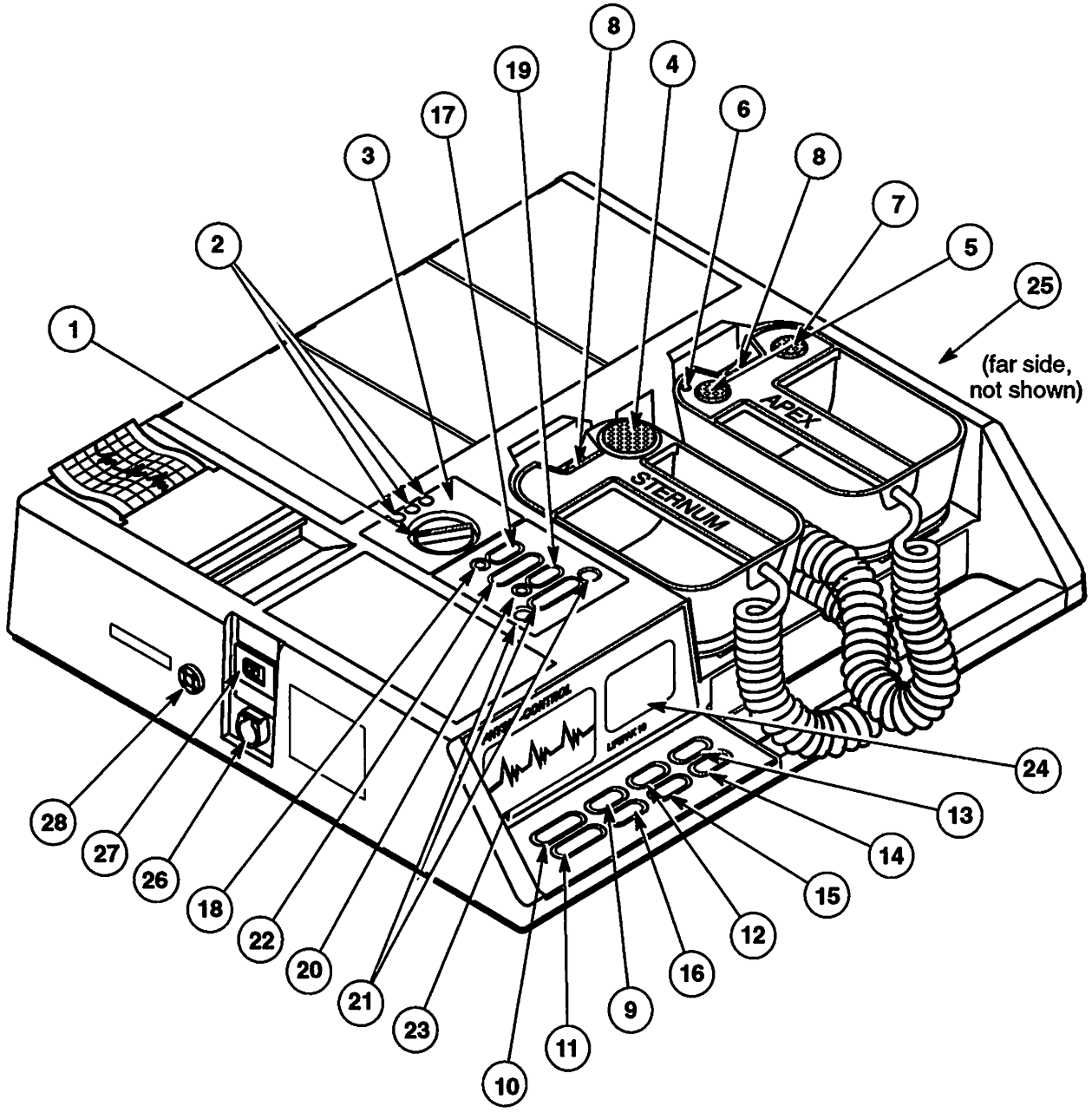

Figure 2–1 LIFEPAK 10 defibrillator/monitor/pacemaker Controls and Indicators

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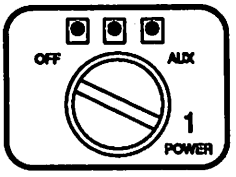
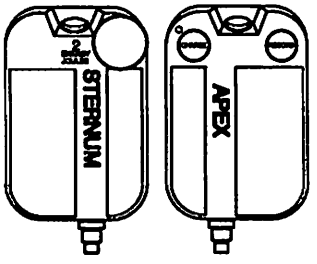
Table 2–1 LIFEPAK 10 defibrillator/monitor/pacemaker Controls and Indicators

Item	Control or Indicator	Function
Power:		
1	OFF	Disconnects power from the instrument.
2	Battery 1, 2, 3	Rotating POWER to one of these battery indicators connects instrument circuitry to the battery installed in the corresponding compartment. Each battery has an associated LED that flashes at low battery or steadily illuminates to identify a depleted battery.
3	AUX	Allows instrument to draw operating power from Auxiliary Power Module (if connected).
Paddles:		
4	ENERGY JOULES	A rotary control to select one of the following energy ranges: 0J, 5J, 10J, 20J, 50J, 100J, 200J, 300J, and 360J. Rotating this switch internally discharges any available energy. The instrument cannot be charged when 0J is selected.
5	CHARGE (amber)	Press to charge to the selected energy. Pressing this button also deactivates the pacemaker and resets pacing modes, if selected.
6	Charge Indicator (amber)	Illuminates when CHARGE is pressed. Flashes on and off as the defibrillator is charging. Glows steadily when selected charge is reached. Off at all other times.
7	RECORD (grey)	This pushbutton functions identically to the RECORD pushbutton on the Main Control Panel (item 15 in this table). May be programmed for diagnostic frequency response (described on p. 2–8, Options Mode Selection and Programming). When this feature is active, pressing and holding RECORD for one second selects the diagnostic mode and displays **DIAG** on the Status Display. The Recorder prints a diagnostic quality ECG signal.

(continued on next page)

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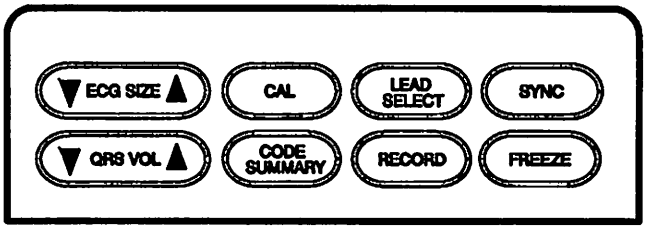
Table 2–1 LIFEPAK 10 defibrillator/monitor/pacemaker Controls and Indicators

Item	Control or Indicator	Function
8	Discharge	Depress both DISCHARGE (red–domestic; black/amber–international) pushbuttons to discharge the instrument. During synchronized cardioversion, they must be held until a QRS is detected.
Main Control Panel:		
9	CAL (black)	Simulates a 1mV calibration signal applied to the ECG leads. Inhibited during SYNC mode. *Refer to Options Mode Selection and Programming (page 2–8) for information about using this pushbutton in the options mode.*
10	▼ECG SIZE▲ (black)	Adjusts vertical size of ECG trace on the CRT and Recorder. Size may be varied from 0.2cm/mV to 4cm/mV in 0.2cm/mV steps. *Refer to Options Mode Selection and Programming (page 2–8) for information about using this pushbutton in the options mode.*
11	▼ QRS VOL ▲ (black)	Adjusts volume of QRS beeper. *Refer to Options Mode Selection and Programming (page 2–8) for information about using this pushbutton in the options mode.*
12	LEAD SELECT (grey)	Selects type of lead for ECG input: PADDLES, I, II, or III. Selecting Paddles suppresses the diagnostic mode but does not clear it.
13	SYNC (grey)	Toggles the instrument in and out of synchronized (SYNC) cardioversion mode. **SYNC** appears on Status Display when SYNC is selected. SYNC (QRS) marks are displayed as bright spots on the R wave. The instrument reverts to the SYNC-off state following a defibrillator discharge. Inhibited when instrument is charged and both discharge pushbuttons are pressed.

(continued on next page)

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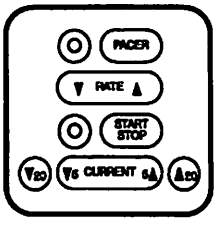
Table 2–1 LIFEPAK 10 defibrillator/monitor/pacemaker Controls and Indicators

Item	Control or Indicator	Function
14	FREEZE (blue)	Freezes the ECG display on the CRT while depressed. If the Recorder is running, it will continue to display a delayed trace. Upon release of FREEZE, the Recorder prints out the ECG that had been frozen on the CRT.
15	RECORD (grey)	Toggles the Recorder on and off. May be programmed for diagnostic frequency response. When this feature is active, pressing and holding RECORD for one second selects the diagnostic mode and displays **DIAG** on the Status Display. The Recorder prints a diagnostic quality ECG signal. Press RECORD again to clear the diagnostic mode and turn the Recorder off.
16	CODE SUMMARY (black)	Prints a summary of data for up to 50 critical events including defibrillation, pacing and ECG. Push once to start printing, push again to stop. Data is retained in memory for up to five minutes after instrument power is off.
Pacemaker Control Panel (with Pacemaker Option):		
17	PACER (grey)	Turns pacemaker power on or off. Allows user to confirm the QRS detection and adjust the ECG size without delivering current. At power-on the initial current and rate are set to minimum regardless of any previous settings.
18	LED Indicator (green)	Indicates the pacemaker is on.
19	START/STOP (red)	Starts or stops pacing. The pacing electrodes must be attached to start pacing.
20	LED Indicator (green)	Indicates pacemaker current output is enabled. The LED blinks off for each pacing pulse actually delivered to the patient.
21	▼ CURRENT ▲ (grey)	Increase or decrease pacing current. Adjustable from 0mA to 200mA in 5mA or 20mA increments.
22	▼ RATE ▲ (grey)	Increases or decreases pacing rate from 40bpm to 170bpm in 10bpm increments.

(continued on next page)

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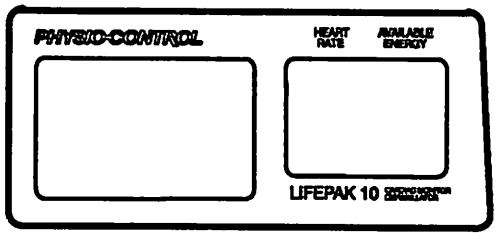
Table 2–1 LIFEPAK 10 defibrillator/monitor/pacemaker Controls and Indicators

Item	Control or Indicator	Function
Displays:		
23	CRT DISPLAY (cardioscope)	Allows viewing of the ECG waveform and QRS (SYNC) marks (when in SYNC mode).
24	STATUS DISPLAY	Displays alphanumeric information about heart rate, available energy, lead selected, SYNC mode, DIAG mode, pacing current and rate, pacing electrode connection message (LEADS), and service indicator. Refer to Table 2–2 and Table 2–3, Status Display Indicators and Status Display Messages, for a listing of all the information available on this display.
External Connectors:		
25	ECG Connector	Not shown, located on side of case next to paddles. Allows connection of 6-pin (3-lead) patient cable for patient signal input.
26	AUX Connector	Allows either one of two connections: • Input power from AC or DC Auxiliary Power Module • Output of modulated or unmodulated ECG (1V/mV ECG) or QRS marks. *For protection during shipping, a black plug is inserted into the* AUX *Connector. Be sure to remove and discard this black plug when unpacking and preparing the instrument for use.*
27	Pacemaker Connector	Allows connection to pacing cable.
28	MIEMSS Modulator Connector (optional)	Allows simultaneous output of two modulated and one unmodulated ECG.

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Status Display Indicators and Messages

Table 2-2 lists the indicators that may appear during the normal operation of the instrument and describes the function of each. Table 2-3 lists operating messages and the circumstances in which they appear.

Table 2–2 Status Display Indicators

Indicator	Function
SYNC	Illuminates during the SYNC mode, blinks off at each detected QRS.
DIAG	Appears only with the "Normal Operation" message mode (see Table 2-3, Messages) and only for diagnostic frequency response mode.
Service Indicator	Appears and remains on if any of the built-in tests encounters a possible failure. Indicates need for prompt service or repair if it remains on. May flash briefly after paddle discharge buttons are pushed.
Lead select	Indicates which one of four leads has been selected: PADDLES, I, II, or III.
Pacemaker Current	Indicates the current dosage in mA that will be delivered into a 700Ω load.
HEART RATE Display	Displays a 3-digit number during normal operation, and "defib charging", and "defib ready" messages as appropriate. The HEART RATE display range is 20bpm to 295bpm (or - - - otherwise). Accuracy is ±4% or ±3bpm, whichever is greater. The display updates once every three seconds. Response time to a change in actual heart rate is less than 15 seconds.
AVAILABLE ENERGY	**With pacemaker off**: displays available defibrillator energy (0-360J). Displays **0** if instrument is not charging. Number updates every second during charging. **With pacemaker on:** displays selected pacing current (0-200mA).

Display Translations	English	French	German	Spanish
	LEADS	DERIVATION	ABLEITUNGEN	DERIVACIONES
	SYNC	SYNC	SYNC	SINC
	SET	REGL	EING	AJUS
	mA	mA	mA	mA
	DIAG	DIAG	DIAG	DIAG

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Table 2–3 Status Display Messages

Description	Displayed Message	Notes
Power-on	(ALL SEGMENTS)	All LCD segments are displayed
Normal Operation (Heart rate=60)	60 0 J (LEAD)	
Defib charging	--- 123 J (LEAD)	
Defib ready (360J)	--- 360 J (LEAD)	
Attempt to activate pacemaker while paddles in use	60 0 LEADS J (PADDLES)	LEADS annunciator flashes 3 times
Pacemaker on (rate = 80)	080 SET 0 mA (LEAD)	
Pacemaker electrode disconnected while pacemaker started	080 SET 0 LEADS mA (LEAD)	LEADS annunciator flashes 3 times
Recorder and CRT diagnostic mode	--- 0 J (LEAD) DIAG	

Options Mode Selection and Programming

The options mode allows access to configuration, calibration, and diagnostic failure code information stored in EEROM. Figure 2–2 provides a step-by-step flow chart to aid when accessing the options mode. Table 2–4 lists and defines the various options modes o01 through o11. Table 2–5 defines the initial options mode selections when the instrument is shipped from the factory.

To activate the options mode, first rotate the POWER switch to OFF. Install a battery in position 1. Then insert the programming key into the AUX connector, rotate the POWER switch to the battery 1 position, and remove the programming key.

Confirm that **o01** appears on the Status Display indicating entry into the options mode.

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- Pressing ▼ ECG SIZE ▲ changes the option numbers
- Pressing ▼ QRS VOL ▲ changes the status of the option number
- Pressing CAL enters the selection into memory (a beep sounds confirming the selection is entered)
- Pressing FREEZE changes from options mode to other types of data.

To exit the options mode, wait at least one full second after pressing CAL to allow sufficient time for the changes to be stored in memory, then rotate the POWER switch to OFF.

Caution

Possible Corruption of Defibrillator Constants and Options Settings. When changing status selections or values in the options mode, after pressing CAL to enter the new value wait at least **one full second** before rotating the POWER switch to OFF to allow the System PCB microprocessor sufficient time to properly store the changes. If power is removed in less than one second, the EEROM memory contents may be corrupted, including the defibrillator calibration constants and the options mode status selections. If the EEROM memory contents are corrupted, the instrument will display the service indicator symbol indicating a failure code has been recorded. To investigate the failure, refer to Figure 2–2 (page 2–10) and Status Display Failure Codes (page 3–40). To restore the correct EEROM memory contents, reselect the proper options mode status selections and perform the Test and Calibration Procedures (TCP) for TCP-Defibrillator Calibration, TCP-AVAILABLE ENERGY Display, and TCP-Recorder Calibration (beginning on page 3–27).

Note: *Since the options mode settings are stored in EEROM, if you replace the System PCB (which contains the EEROM) you will lose the current options mode settings. Before removing a System PCB for replacement, be sure to enter the options mode and write down the user's current options mode settings. After installing the new System PCB, be sure to enter the options mode and reenter these recorded settings. If the user's settings are not available, the original factory settings are listed in Table 2–5 on page 2–12.*

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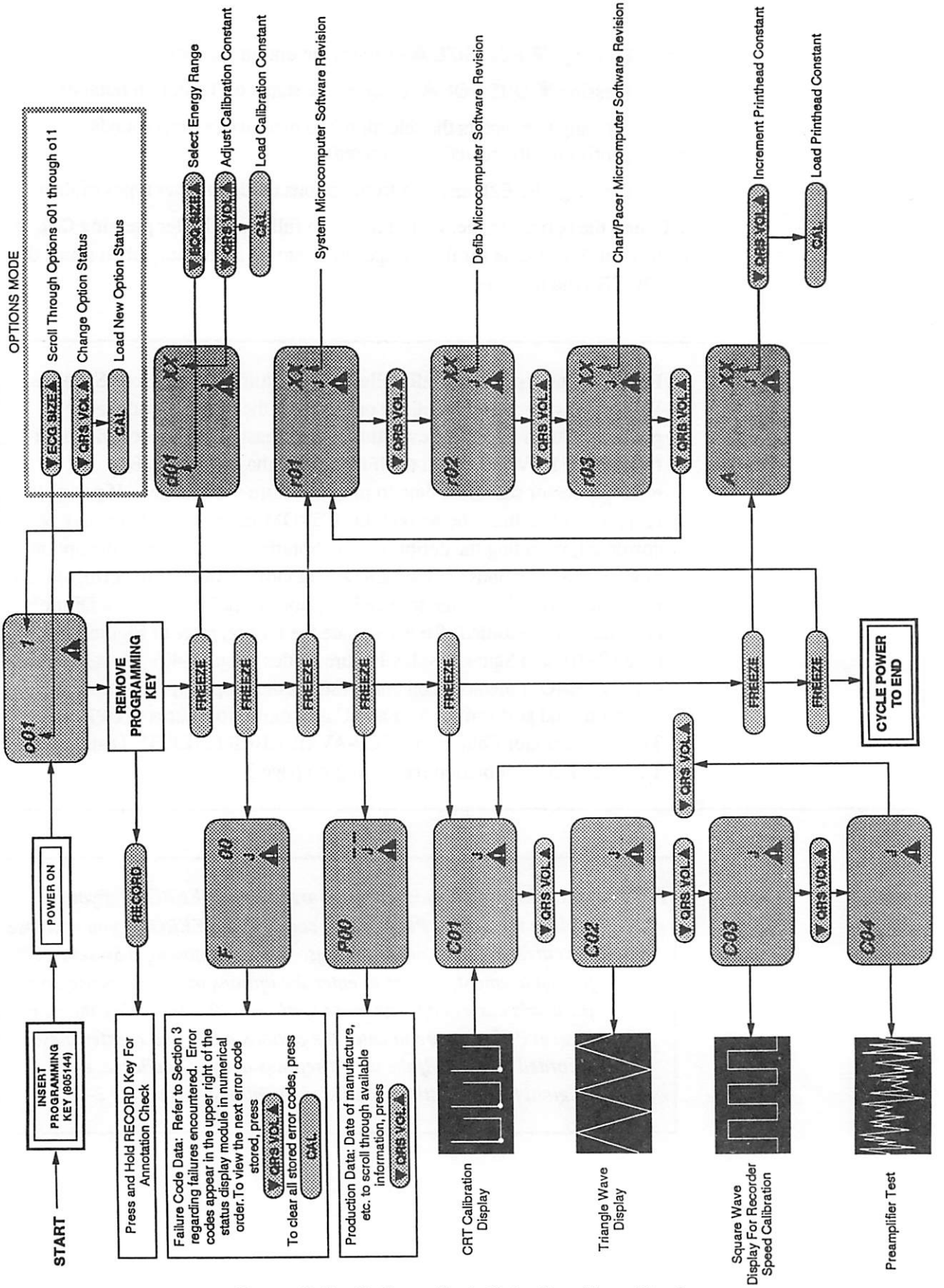

Figure 2–2 Options Mode Selection Flow Chart

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Table 2–4 Description of Options Mode Selections

Option Number	Description	Status Selection
o01	Allows Recorder to be placed in diagnostic mode.	0 = no 1 = yes
o02	If yes, the energy charge level is displayed on the Status Display.	0 = no 1 = yes
o03	If yes, the service/failure symbol will be displayed on the LCD for some failure conditions.	0 = no 1 = yes
o04	Determines the frequency response specifications for the Cardioscope and Recorder (See Table 1–1 on page 1–4).	0 = agency 1 = domestic
o05	(Not implemented)	(not applicable)
o06	Defines the maximum pacing rate available.	0 = 170 1 = 140
o07	Selects the language displayed on the Status Display.	0 = English 1 = French 2 = German 3 = Spanish
o08	Determines the lead selected when the instrument powers on.	0 = lead II 1 = paddles
o09	Determines the line power notch filter frequency.	0 = 50Hz 1 = 60Hz
o10	Determines the type of signal available at the AUX connector.	1 = ECG 2 = Modulated ECG 3 = QRS 4 = Serial data
o11	Enables the notch filter on the ECG leads for diagnostic frequency response. (The notch filter is not needed and not available on the ECG leads for monitor frequency response; the notch filter is always enabled in paddles.)	0 = no 1 = yes

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Table 2–5 Factory Settings for Options Mode Selections

Instrument Dash Number (804200-xx)	Option Number										
	o01	o02	o03	o04	o05	o06	o07	o08	o09	o10	o11
–14	1	1	1	1	1	0	0	0	1	2	0
–15	1	1	1	1	1	0	2	0	0	2	0
–16	1	1	1	0	1	0	1	0	0	2	0
–17	1	1	1	1	1	0	3	0	0	2	0
–18	1	1	1	1	1	0	0	0	0	2	0
–19	1	1	1	1	1	0	0	0	1	2	0
–20	1	1	1	1	1	0	2	0	0	2	0
–21	1	1	1	0	1	0	1	0	0	2	0
–22	1	1	1	1	1	0	3	0	0	2	0
–23	1	1	1	1	1	0	0	0	0	2	0
–24	1	1	1	1	1	0	0	0	1	2	0
–25	1	1	1	1	1	0	0	0	1	2	0
–26	1	1	1	1	1	0	1	0	1	2	0
–27	1	1	1	1	1	0	1	0	1	2	0
–28	0	1	1	1	1	0	0	0	1	1	0
–29	0	1	1	1	1	0	2	0	0	1	0
–30	0	1	1	0	1	0	1	0	0	1	0
–31	0	1	1	1	1	0	3	0	0	1	0
–32	0	1	1	1	1	0	0	0	0	1	0
–33	0	1	1	1	1	0	0	0	1	1	0
–34	0	1	1	1	1	0	2	0	0	1	0
–35	0	1	1	0	1	0	1	0	0	1	0
–36	0	1	1	1	1	0	3	0	0	1	0
–37	0	1	1	1	1	0	0	0	0	1	0
–38	0	1	1	1	1	0	0	0	1	1	0
–39	0	1	1	1	1	0	0	0	1	1	0
–40	0	1	1	1	1	0	1	0	1	1	0
–41	0	1	1	1	1	0	1	0	1	1	0
–42	0	1	1	1	1	0	0	0	1	1	0
–43	0	1	1	1	1	0	0	0	1	1	0
–44	0	1	1	1	1	0	0	0	0	1	0
–45	0	1	1	1	1	0	0	0	1	1	0
–46	0	1	1	1	1	0	0	0	1	1	0

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CODE SUMMARY

The CODE SUMMARY feature provides a printed record of details about critical events including defibrillation, pacing, and ECG monitoring. The CODE SUMMARY memory consists of 32KB of RAM. The recording of CODE SUMMARY events in memory is initiated whenever the operator initiates defibrillation, activates pacing, or activates the recorder. The CODE SUMMARY information is printed out when the operator presses the CODE SUMMARY pushbutton. An internal battery maintains power to the RAM to retain the CODE SUMMARY information for up to five minutes after the POWER switch is turned to OFF. After five minutes without power, CODE SUMMARY information is erased. Printing CODE SUMMARY information does not affect the contents of CODE SUMMARY RAM. The CODE SUMMARY information can only be deleted by removing power from the instrument for more than five minutes.

CODE SUMMARY can store information for a maximum of 50 events. Examples of event information are shown in Figure 2–3. Information may include two parts: a "preamble" and the ECG trace. The preamble consists of the time, date, and event parameters. The ECG trace consists of ECG information and event parameters.

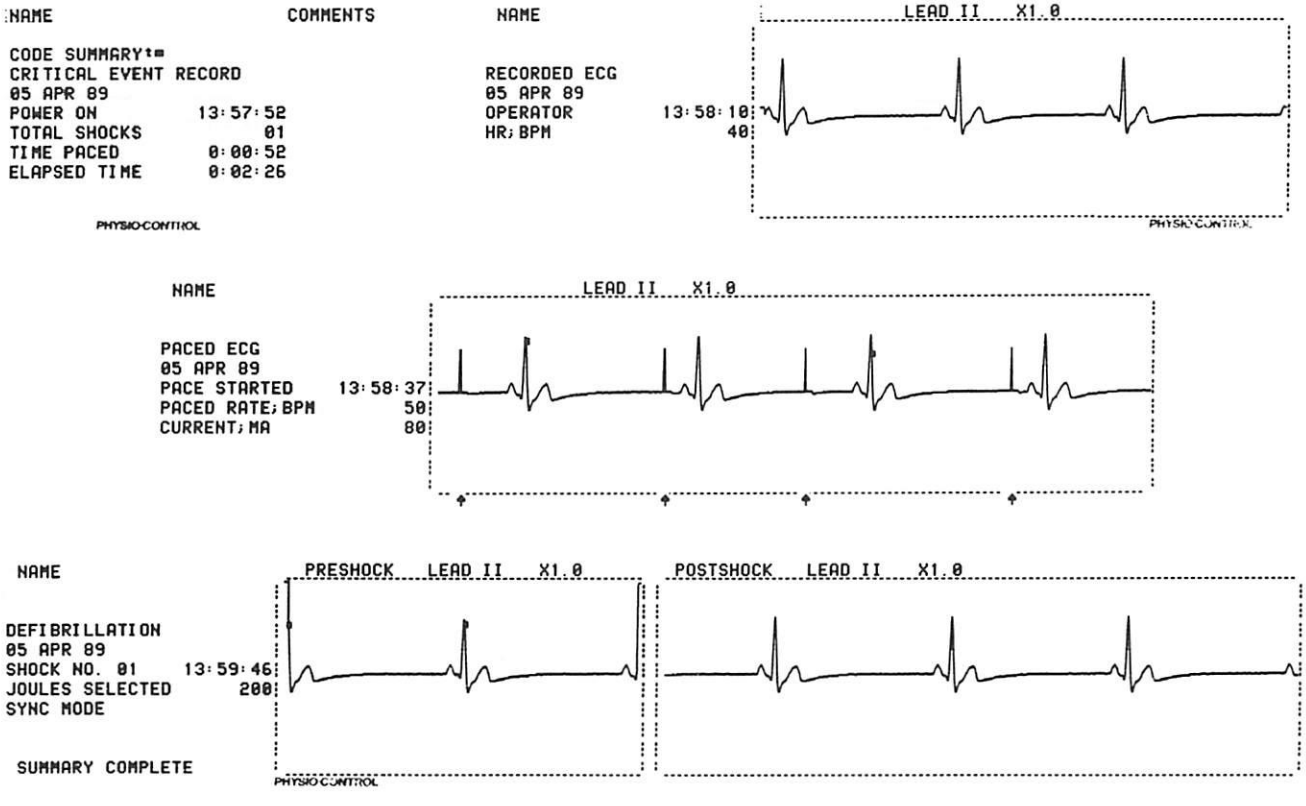

Figure 2–3 Sample CODE SUMMARY Recorder Printout

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For a Record Event, the ECG trace includes 6 seconds of ECG: 3 seconds before and after the RECORD pushbutton is pressed to activate the recorder. For a Pacing Event, the ECG trace includes 6 seconds of ECG after pacing is activated and controls remain unchanged for 10 seconds. For a Defibrillation Event, the ECG trace is blanked for 3 seconds immediately after the shock; the ECG trace includes 3 seconds before the shock, and 5.5 seconds after the 3 second blanking period.

Events are stored in chronological order as they occur. All 50 events include preamble information, but because of memory limitations, only 22 of the events can also include the ECG trace. After the first 22 events are stored, subsequent events are stored according to the following priority:

Priority 1:	Defibrillation Events
Priority 2:	Pacing Events
Priority 3:	Recorder Events

The storage of CODE SUMMARY information is summarized in Table 2–6. Note that after 22 events are stored, subsequent higher-priority events may record the ECG trace over previously recorded lower-priority events. In general, the last event recorded includes both preamble and ECG trace.

Table 2–6 Information Stored in CODE SUMMARY RAM

Event	Recorder Event	Pacing Event	Defibrillation Event
1-22	Preamble + ECG.	Preamble + pacing/ECG.	Preamble + defib/ECG.
23-50	Stores preamble only (no ECG) except for last event (see below).	Stores preamble. Also looks for a lower priority Recorder Event X between 1-22. If found, also stores pacing/ECG causing Event X to retain only preamble. (For last event, see below.)	Stores preamble. Also looks for a lower priority Recorder or Pacing Event X between 1-22. If found, also stores defib/ECG causing Event X to retain only preamble. (For last event, see below.)
51+	No preamble or ECG except for last event (see below).	No preamble or ECG except for last event (see below).	No preamble or ECG except for last event (see below).
Last Event	Stores preamble. If there exist fewer than 22 previous Pacing or Defib Events, also stores ECG.	Stores preamble. If there exist fewer than 22 previous Defib Events, also stores pacing/ECG.	Stores preamble and defib/ECG data.

The time of day is printed on the border of the recorder paper at print time. The time information is also printed as part of the CODE SUMMARY information. The supply voltage level is monitored to protect the RTC and RAM data if battery voltage falls too low.

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Setting the Real-Time Clock

Set the real-time clock to the current day, date, and time by performing the following steps:

1. Activate the clock-set mode by pressing and holding RECORD on the APEX paddle while rotating the POWER switch from OFF to the battery 1 position. The numbers flashing in the Status Display heart rate field are the hours digits of the 24-hour clock.

2. To change the hours digits, press the ▼ QRS VOL ▲ pushbutton until the desired value (**1-24**) is displayed.

3. To set the minutes portion of the 24-hour clock, press (▲) on the ECG SIZE pushbutton until the digits in the available energy field of the Status Display begin to flash. Press (▲) on the QRS VOL until the desired minutes value (**1-59**) is displayed.

4. To set the month, press (▲) on the ECG SIZE pushbutton until the digits in the heart rate field of the Status Display begin to flash. Press ▼ QRS VOL ▲ until the desired month (**1-12**) is displayed.

5. To set the day, press (▲) on the ECG SIZE pushbutton until the digits in the available energy field of the Status Display begin to flash. Press ▼ QRS VOL ▲ until the desired day (**1-31**) is displayed.

6. To set the year, press (▲) on the ECG SIZE pushbutton until the digits in the heart rate field of the Status Display begin to flash (in this mode, the available energy field is blank). Press ▼ QRS VOL ▲ until the desired year (**00-99**) is displayed.

> ***Note:*** *The year 2000 is displayed as "00", 2001 is displayed as "01", etc.*

7. To terminate the clock-set mode, rotate the POWER switch to OFF.

Confirm the proper clock setting by turning instrument power on and pressing RECORD after the self test is complete. The printed strip should confirm the proper time and date.

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Testing 3

Introduction

This section describes how to test, calibrate, and troubleshoot the LIFEPAK 10 defibrillator/monitor/pacemaker. Topics cover:

- The Performance Inspection Procedure (PIP)
- The Test and Calibration Procedure (TCP)
- Troubleshooting Aids.

> ***Note:*** *Prefixes are used to distinguish testing steps.*
> **PIP—** *identifies Performance Inspection Procedure steps.*
> **TCP—** *identifies Test and Calibration Procedure steps.*

Performance Inspection Procedure

This Performance Inspection Procedure (PIP) checks whether a LIFEPAK 10 defibrillator/monitor/pacemaker is functioning within specifications. The instrument case does not need to be opened to perform the PIP. The PIP Checklist (page 3–19) may be photocopied and used to record the PIP results. If the instrument fails any part of the PIP, refer to the Test and Calibration Procedure (page 3–20) and the Troubleshooting Aids (page 3–36) for help in locating any failed subassemblies.

PIP-Purpose

This PIP checks whether the LIFEPAK 10 defibrillator/monitor/pacemaker is functioning within specifications. Perform the PIP regularly as a periodic maintenance check and after any repair or calibration.

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PIP-Scope and Applicability

This PIP applies to all LIFEPAK 10 defibrillator/monitor/pacemakers. Two of the steps apply only if the pacemaker option is installed. This PIP does not apply to the AC or DC Auxiliary Power Module or the Battery Support System; refer to their respective service manuals for testing information.

PIP-Definitions

Acronyms used in this procedure are:

ECG	Electrocardiogram
PIP	Performance Inspection Procedure
QRS or QRS Complex	Refers to portions of the ECG waveform
NSR	Normal Sinus Rhythm

> ***Note:*** *Pushbuttons are indicated in* CAPITAL LETTERS *and displayed messages are indicated in* **BOLD CAPITAL LETTERS.**

PIP-Requirements

The requirements for test equipment, workstation, and personnel are listed below along with important safety information.

PIP-Required Equipment

Performing this PIP requires the equipment listed in Table 3–1. Although specific test instruments are recommended, other test equipment with equivalent specifications may be used.

Table 3–1 PIP Test Equipment

Equipment	Specifications	Manufacturer
Defibrillator Energy Meter	Power Range: 0-400J Load Resistance: 50Ω ±10% Accuracy: ±3%	Bio-Tek QED-6 or equivalent*
ECG simulator	Accuracy: 1% of selected rate	Bio-Tek QED-6 or equivalent*
12-Lead ECG Patient Simulator**	Accuracy: 0.5% of selected rate Outputs: 12-lead ECG	Dynatech Nevada 215A, or equivalent*
Pacemaker Tester	Current/Voltage Accuracy: ±2% of reading Pulse Width Measurement Accuracy: ±0.5%	Bio-Tek QED-6 or equivalent*

* Equivalent equipment is required to meet the specifications listed in the specifications column.

** Required only for testing the optional 12 lead ECG adapter.

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Equipment	Specifications	Manufacturer
Leakage Tester/ Safety Analyzer	Current Accuracy: ±1% Resistance Accuracy: ±1%	Dynatech Nevada 232, or equivalent*
LIFEPAK 10 Programming Key		Physio-Control PN 805144 (provided with instrument)
AC or DC Auxiliary Power Module		Physio-Control
Timer	1 second resolution	

* Equivalent equipment is required to meet the specifications listed in the specifications column.
** Required only for testing the optional 12 lead ECG adapter.

PIP-Test Equipment Validation

All test equipment used in performing the PIP must have a current calibration label affixed to its exterior. The calibration label must be issued by a certified calibration facility.

PIP-Workstation

If ac line power is provided to this workstation it must be connected to a grounded power source.

PIP-Personnel

Personnel performing this PIP must be thoroughly familiar with the operation of the LIFEPAK 10 defibrillator/monitor/pacemaker. In addition, personnel performing this PIP must meet at least one or more of the following levels of education or experience:

- Associate of applied science degree with a major emphasis in biomedical electronics
- Certificate of technical training in electronics with a major emphasis in biomedical electronics
- Equivalent biomedical electronics experience.

Warning

SHOCK HAZARD. When charged and discharged during this PIP, the LIFEPAK 10 defibrillator/monitor/pacemaker discharges up to 360J of electrical energy through the defibrillator paddles. This electrical energy must be safely discharged as described in this PIP. Do not attempt to perform this procedure unless you are thoroughly familiar with the operation of the LIFEPAK 10 defibrillator/monitor/pacemaker.

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PIP-General Instructions

The following sections are the actual PIP steps to be performed. These steps are designed to be executed in sequential order. For instance, if a heart rate input of 30bpm is specified for one test it also applies to the next test unless you are instructed to change it.

> *Note: In order to perform this PIP, you may need to change some of the user's current options mode settings as described on page 2–8. Before performing the PIP, enter the options mode and write down the current settings. After the PIP is completed, be sure to reenter the options mode and restore the settings to their original values.*

Caution

Possible Corruption of Defibrillator Constants and Options Settings. When changing status selections or values in the options mode, after pressing CAL to enter the new value wait at least **one full second** before rotating the POWER switch to OFF to allow the System PCB microprocessor sufficient time to properly store the changes. If power is removed in less than one second, the EEROM memory contents may be corrupted, including the defibrillator calibration constants and the options mode status selections. If the EEROM memory contents are corrupted, the instrument will display the service indicator symbol indicating a failure code has been recorded. To investigate the failure, refer to Figure 2–2 (page 2–10) and Status Display Failure Codes (page 3–40). To restore the correct EEROM memory contents, reselect the proper options mode status selections and perform the Test and Calibration Procedures (TCP) for TCP-Defibrillator Calibration, TCP-AVAILABLE ENERGY Display, and TCP-Recorder Calibration (beginning on page 3–27).

PIP-Physical Inspection

- Inspect all exterior surfaces for signs of abuse or other damage, including fluid spills, cracks and dents.
- Inspect paddles for pitted electrode plates, presence of dried defibrillation gel, and integrity of cables and switches. Remove gel or other foreign matter from paddles.
- Inspect Recorder for ease of door operation and positive latching. Remove dust or foreign matter inside Recorder.
- With no batteries installed, cycle the POWER switch to confirm that the knob is tight on the shaft and the switch indexes properly. Return the switch to the OFF position.
- Inspect all external connections for bent, broken, or corroded pins, and debris.

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- Press all pushbuttons and check them for uniform feel.
- Inspect all cables and accessories for damage, cracks, breaks, bent or broken connector pins, or other signs of wear.
- Inspect the battery connector pins for wear and replace any pins which appear bent, broken, loose, corroded, worn, or damaged. For replacement information, refer to page 4–7.

PIP-Power-on Sequence

Install a FASTPAK battery in the battery 1 receptacle.

1. Connect the ECG simulator to the instrument (no power to the simulator). Turn on the instrument by rotating the POWER switch from OFF to the battery 1 position.
2. Confirm that the instrument powers up with Lead **II** or **Paddles** indicated on the lower left of the Status Display. The default lead configuration is a programmable selection. Refer to Options Mode Selection and Programming (page 2–8) for information on changing the default lead configuration.
3. Confirm that the display is backlit and clearly visible.
4. Confirm that the Status Display shows three dashes in the upper left corner and the symbol **OJ** in the upper right, and that all other annunciators are not displayed.

PIP-Fault Stack Check

Checking the Fault Stack allows you to access the self-diagnostic feature of the LIFEPAK 10 defibrillator/monitor. If a failure occurs, the appropriate failure code(s) is logged and a qualified service technician can read and record it. Table 3–9 (page 3–40) lists all the possible failure codes and corresponding failures.

1. Rotate the POWER switch to OFF and insert the Programming Key into the AUX connector. Rotate POWER to battery 1 and remove the Programming Key. The instrument is now in the options mode.
2. Press the FREEZE button twice to scroll to the failure code data screen.

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3. Write down a list of any displayed failure codes (press QRS VOL to sequentially display the numerical codes; any number other than 00 is a failure code). Retain this list of recorded failure codes for possible use if other failure codes are logged during this PIP and troubleshooting is required.

4. Press CAL to clear any failure codes.

5. Rotate the POWER switch to OFF to exit the options mode.

PIP-Paper-Out Sensor and Recorder Speed

Use the ECG simulator to input a 1mV, 60bpm NSR signal through the ECG cable. Install a roll of paper in the Recorder.

1. Turn on the instrument by rotating the POWER switch from OFF to the battery 1 position.

2. Confirm an NSR waveform displays on the CRT.

3. Open the Recorder door and press RECORD. Confirm the Recorder does not operate.

4. Close the Recorder door. Press RECORD on the main control panel and confirm that the Recorder prints the NSR waveform on the paper.

5. Check that the time and date on the printout are correct.

6. Press RECORD on the APEX paddle to turn off the Recorder.

7. Confirm that the spacing between R wave peaks is 25 ±1mm.

PIP-CODE SUMMARY

1. Charge the defibrillator to 100J and discharge the energy into the external energy meter.

2. Press CODE SUMMARY, the recorder will start running, confirm the information on the strip indicates a 60bpm heart rate from the Recorder Speed check and a defibrillator discharge from the previous step.

PIP-Freeze and ECG Audio Checks

Select Lead II and allow the display to show QRS complexes over its full width.

1. Press QRS VOL (▲) repeatedly until you hear a beep. Then press and hold QRS VOL (▲) and confirm the beep gets louder. Then press QRS VOL (▼) until the tone is inaudible.

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2. Press RECORD to start the Recorder.

3. After annotations are printed on the Recorder, press FREEZE and confirm the waveform halts for as long as the pushbutton is held.

4. Release FREEZE and confirm the Recorder prints the ECG trace that was frozen on the display as indicated by the annotation at the bottom of the Recorder paper.

5. Press RECORD to turn off the Recorder and confirm that the strip shows the correct time, lead setting, and heart rate across its top, and an ECG waveform is printed on its full length.

PIP-Preamplifier Baseline Noise and CAL Pulse Checks

1. Disconnect the LL and RA patient cable leads from the ECG simulator (red and white leads for AHA cable, green and red leads for IEC cable). Press the LL and RA metal cable leads together so they are electrically shorted.

2. Press LEAD SELECT (as necessary) to select Lead II. Press ECG SIZE (▲) four times.

3. Press RECORD and confirm that the selected ECG size is x1.8. Confirm also that the Recorder prints a trace with a thickness less than 1mm. Press ECG SIZE (▼) four times so ECG size is x1.0, then press RECORD to turn off the Recorder.

4. Press and hold RECORD for more than 2 seconds to select diagnostic response.

> *Note: If* **DIAG** *does not appear in Status Display confirming diagnostic response, refer to Options Mode Selection and Programming, page 2–8, and reprogram the instrument to enable the diagnostic response.*

5. Press CAL. Confirm that the Recorder prints a pulse which has a vertical leading edge of 10 ±1mm. Press RECORD to turn the Recorder off.

PIP-Heart Rate and Lead Polarity

1. Connect the patient cable to the ECG simulator and select a 1mV, 30bpm NSR signal.

2. Select Lead I and confirm the displayed heart rate is between 27bpm and 33bpm.

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3. Input a heart rate of 240bpm. After 15 seconds confirm the displayed heart rate is between 233bpm and 247bpm.
4. Select Lead **II** and confirm the signal polarity is the same as Lead **I**.
5. Select Lead **III** and confirm the signal polarity is the same as Lead **I**.

PIP-Synchronized Cardioversion

Select Lead **II**, increase the QRS volume so it is clearly audible, and change the ECG rate to 30bpm.

1. Press RECORD, then SYNC. Confirm that the QRS sense markers appear on the CRT with each QRS complex.
2. As the first marked complex moves off the left side of the CRT screen, confirm that it is printed on the recorder paper.
3. Press RECORD to turn the Recorder off.
4. Confirm that the **SYNC** annunciator is visible on the Status Display, and that it blinks with each detected R wave.
5. Connect paddles to the external energy meter.
6. Charge the defibrillator to 100J.
7. Wait for an interval between QRS complexes. Press and hold one discharge pushbutton for at least one QRS complex. Confirm that the defibrillator does not discharge.
8. Press and hold the other discharge pushbutton for at least one QRS complex. Confirm that the defibrillator does not discharge.
9. Press and hold both discharge pushbuttons and confirm the CRT displays the defibrillator discharge when the next QRS complex occurs. Release pushbuttons.
10. Confirm the instrument exits the synchronized mode.

PIP-Warm/Cold Restart Check

When replacing a battery in the instrument, if the power switch is set to an empty battery receptacle for less than 30 seconds, the instrument will return to the same mode it was in before power was removed. This is defined as "warm restart." A "cold restart" is when the instrument *does not* return to the mode it was in before power-off. This occurs when the power is switched to an empty battery receptacle for more than 30 seconds, *or* when the power switch is set to OFF.

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PIP-Warm Restart

1. With the instrument operating from battery 1, select Lead **III**. Remove the battery from battery 1 receptacle and insert it into battery 2 receptacle. Within 15 seconds perform steps 2 through 5 below.
2. Confirm the instrument is off.
3. Rotate the POWER switch to battery 2.
4. Confirm the instrument powers up without executing the full "cold start" routine.
5. Confirm Lead **III** selection is retained.
6. Repeat steps 2 through 5 for battery receptacles 3 and 1 (moving the battery from battery receptacle 2 to battery receptacle 3, and then from battery receptacle 3 to battery receptacle 1).

PIP-Cold Restart

With the instrument operating from battery 1, select Lead **III**. Rotate the POWER switch to OFF, then rotate it to battery 1.

1. Confirm the full "cold start" routine is executed.
2. Confirm Lead **II** or **Paddles** is selected.

> ***Note:*** *Rotating the* POWER *switch to* OFF *always causes the full "cold start" routine to be executed.*

PIP-Pacemaker Functional Tests

If pacemaker is installed, perform the following tests. Use the ECG simulator to input a 1mV, 30bpm NSR signal through the ECG cable. Press PACER and confirm the green pacemaker LED turns on.

1. Confirm that the Status Display reads **040 SET** and **0mA** and the QRS sense markers on the CRT are displayed.
2. Connect the pacing cable to the PACE connector and pacemaker tester.
3. Press START/STOP and confirm that the indicator illuminates and flashes as each pacing pulse is delivered.
4. Confirm that the output current can be adjusted up to 200 mA and down to 0mA by pressing the **5mA** and **20mA** pushbuttons.

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5. Confirm that the pacing rate can be adjusted up to 170bpm (or 140bpm if maximum set in options mode) and down to 40bpm by pressing the pacing ▼ RATE ▲ pushbuttons.

6. Select **100mA** output current at 80bpm.

7. Confirm that pacing markers (upward, positive-going spikes on the ECG waveform) are visible on the CRT.

8. Press RECORD and confirm that the QRS flags and pacing markers are printed.

> *Note: The pacing markers are the small arrows printed at the bottom edge of the Recorder paper. The QRS flags are the small squares printed on the R wave on the Recorder paper.*

9. Set the ECG simulator to a value greater than 80bpm.

10. Confirm that pacing is discontinued. Turn the Recorder off and reduce the simulator rate to 30bpm, confirming that pacing resumes.

11. Disconnect the pacing cable at the pacing output connector. Confirm that a two-tone alarm sounds and that pacing discontinues.

12. Reconnect the pacing cable and confirm that the Status Display now shows **080 SET** and **0mA**. Press PACER to turn off the pacemaker. Turn off the ECG simulator.

PIP-Pacemaker Output Tests

Connect a pacemaker tester to the instrument patient connector.

1. Press PACER and then START/STOP to turn on the pacemaker. Select a pace rate of 70bpm and a current of 100mA.

2. Confirm that the pacing pulses are delivered to the tester at 70 ±1bpm and the output current is 100 ±3mA.

3. Adjust the pace current to 200mA and the output rate to maximum. Confirm the pulses being delivered to the tester are now 170 ±2bpm (or 140 ±2bpm if 140 is the maximum set in the options mode) and 200 ±6mA.

4. Press PACER to turn off the pacemaker and disconnect pacemaker leads from the tester.

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PIP-Defibrillator Control and QUIK-LOOK

Press LEAD SELECT to select **PADDLES** lead.

1. Confirm the paddle symbol is visible on the Status Display.
2. Hold the ECG simulator connections to the paddles (APEX on LL, STERNUM on RA) and confirm that a positive-going QRS is visible on the CRT.
3. Press and hold ECG SIZE (▲) until you hear three beeps to make sure ECG size is set at maximum.
4. Press the paddle electrodes together so they are electrically shorted. Confirm that the CRT trace returns to the baseline within 3 seconds, with less than 3mm p-p baseline noise present.
5. Press the LEAD SELECT pushbutton to select Lead **II**.
6. Rotate the ENERGY select switch to **0J**. Press CHARGE and confirm that the instrument will not charge.
7. Rotate the ENERGY select switch to **200J**, and press CHARGE. Confirm that the paddle charge indicator flashes at a nominal 1Hz rate, and glows steadily when the charge cycle is completed.

PIP-Energy Output

1. Rotate the ENERGY select switch to **5J**. Press CHARGE and confirm that the defibrillator charges and a brief charging tone sounds.
2. Confirm that when the "ready" state is achieved, the CHARGE indicator illuminates and the ready tone sounds.
3. Confirm that the available energy display indicates the nominal value for the selected range.
4. Discharge the stored defibrillator energy into the defibrillator energy meter. Confirm that the selected energy equals the externally measured energy ±7%.
5. Repeat steps 1 through 4 to confirm each energy selection from 10-360J.
6. Rotate the POWER switch to OFF.

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PIP-Refresh and Auto-Dump

1. Charge the defibrillator to 360J. **Begin timing when charging is completed** (charge light changes from flashing to steady). Confirm that the instrument automatically discharges the stored energy internally (the Energy Indicator blanks) after 60 ±3 seconds.
2. Charge the defibrillator to 360J. Rotate the ENERGY select switch to 5J. Confirm that the instrument automatically discharges internally.
3. Press the PACER and START/STOP pushbuttons. Confirm that pacing is initiated.
4. Charge the defibrillator to 100J. Confirm that pacing is discontinued as soon as the charge is initiated. Discharge the energy into the external energy meter. Confirm that pacing does not automatically resume after energy is discharged into the energy meter. Rotate the POWER switch to OFF.

PIP-External Power Operation

Connect an AC or DC Auxiliary Power Module to the AUX input.

1. Rotate the POWER switch from OFF to the AUX position.
2. Confirm that all Status Display messages, three battery indicators, pacemaker LEDs, and the paddle charge indicator illuminate for approximately 3 seconds and then extinguish.
3. Place the defibrillator paddles on the external energy meter.
4. Charge the defibrillator to 360J and then discharge into the energy meter. Confirm that the discharged energy is between 335J and 385J (±7%).
5. Rotate the POWER switch from AUX to OFF and disconnect the AC or DC Auxiliary Power Module from the AUX input.

PIP-Fault Stack Recheck

Checking the Fault Stack allows you to access the self-diagnostic feature of the LIFEPAK 10 defibrillator/monitor. If a failure occurs while this PIP is performed, the appropriate failure code(s) is logged. Table 3–9 (page 3–40) lists all the possible failure codes and corresponding failures.

1. Rotate the POWER switch to OFF, insert the Programming Key into the AUX connector, and rotate the POWER switch to battery 1.
2. Press the FREEZE key twice to scroll to the failure code data screen.
3. Write down a list of any displayed failure codes (press QRS VOL to sequentially display the numerical codes; any number other than 00 is a

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failure code). If any failure codes are displayed, refer to Table 3–9 (page 3–40), Test and Calibration (page 3–20), and Troubleshooting Aids (page 3–36) to identify and correct the cause for the failure codes.

> ***Note:*** *After you complete the PIP, be sure to enter the options mode (as described on page 2–8) and reenter the user's original settings.*

PIP-Leakage Current

Check leakage current in accordance with AAMI/ANSI (Association for the Advancement of Medical Instrumentation/American National Standards Institute) ES1-1985, AAMI/ANSI DF2-1989, IEC (International Electrotechnical Commission) 601-1 and IEC 601-2-4. Because of the wide variety of Safety Analyzers that may be used for these tests, only general instructions are provided in this manual. See Figure 3–1 and Figure 3–2 for connection diagrams. Refer to your Safety Analyzer operator's manual for instructions about configuring and performing these tests. The maximum allowable leakage current is summarized in Table 3–2 and Table 3–3.

Warning

ELECTRICAL HAZARD. Make sure you are familiar with your test equipment and how to execute these tests. Failure to properly perform these tests could result in not detecting excessive leakage current.

Table 3–2 Maximum Leakage Current for Patient Contact Tests

Patient Contact Tests	Power Source: Battery, DC Auxiliary Module, or AC Auxiliary Module (115 Vac)			Power Source: AC Auxiliary Power Module (230 Vac)		
	ECG Leads	Pacemaker Leads	External Paddles	ECG Leads	Pacemaker Leads	External Paddles
Patient Source Current	10µA	10µA	100µA	50µA	50µA	500µA
Patient Sink Current	10µA*	10µA*	100µA	50µA	50µA	500µA

* Value as measured at patient cable input. If measurement is taken at end of patient cable, add 10µA.

Table 3–3 Maximum Leakage Current for Chassis Leakage Tests

Chassis Leakage Tests	Power Source: Battery, DC Auxiliary Module, or AC Auxiliary Module (115 Vac)	Power Source: AC Auxiliary Power Module (230 Vac)
Ground Intact	100µA	100µA
Ground Open	100µA	500µA

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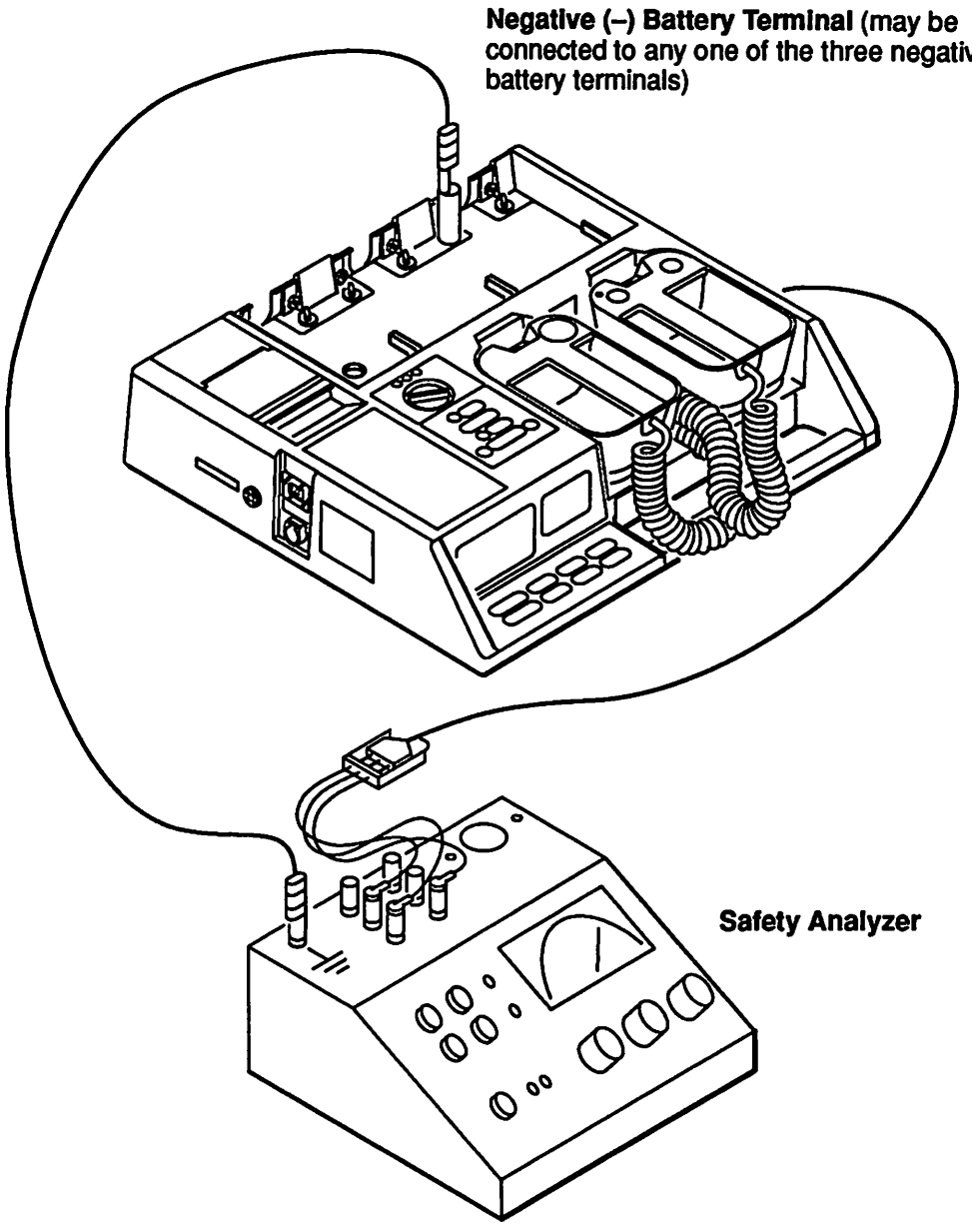

Figure 3–1 Leakage Test Connections without External Power Source

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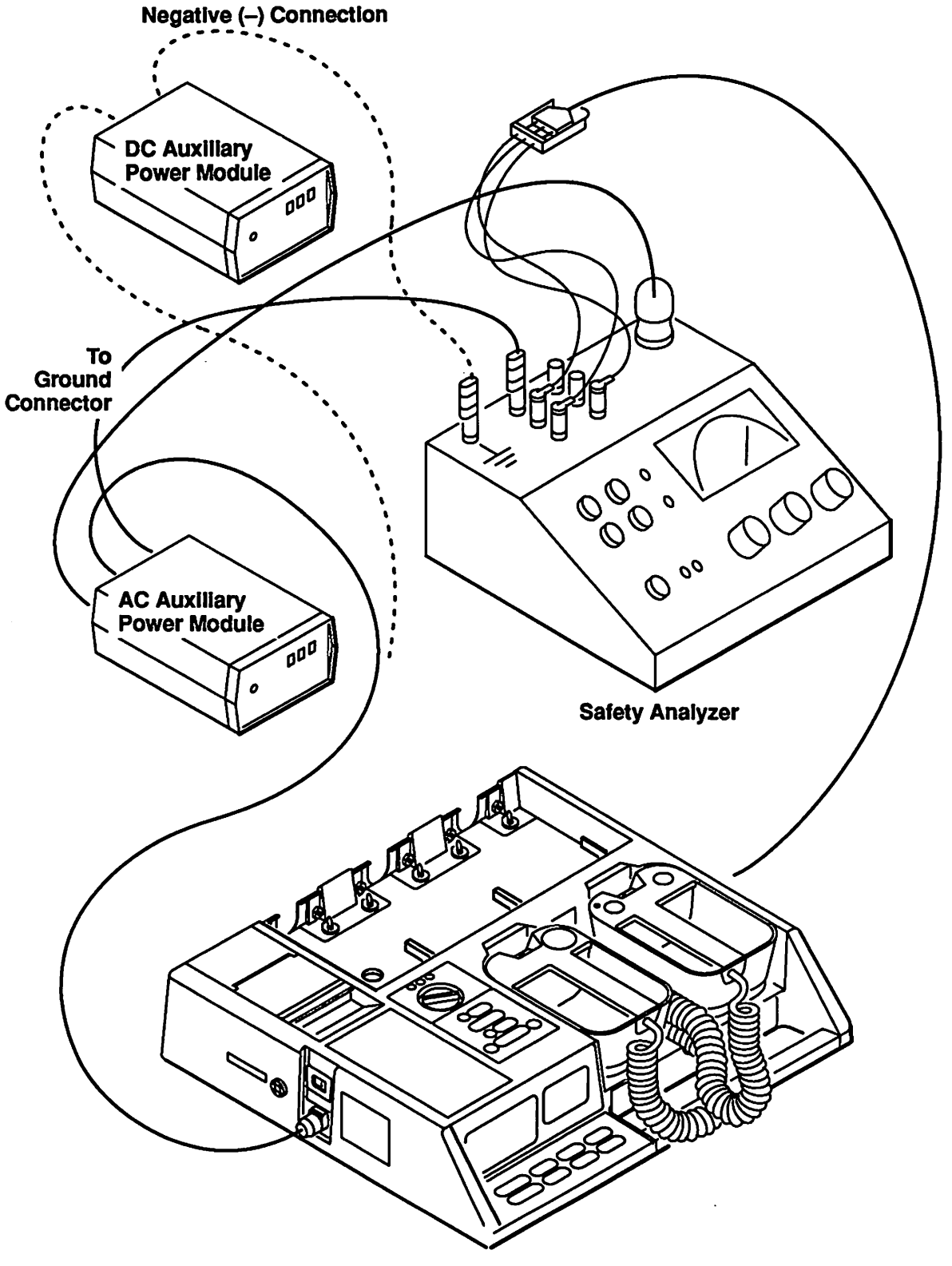

Figure 3–2 Leakage Test Connections with External Power Source

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PIP-12 Lead ECG Adapter (option)

Follow these steps to test the optional 12 lead ECG adapter. This procedure requires use of a 12 lead ECG patient simulator and access to the diagnostic response mode.

1. Connect the 12 lead adapter 6-pin cable to the LIFEPAK 10 defibrillator/monitor/pacemaker patient ECG connector.
2. Connect the 10 snap connectors from the 12 lead adapter to the appropriate connections on the patient simulator.
3. Select 60bpm on the patient simulator.
4. With the instrument POWER switch set to battery 1, press and hold the RECORD pushbutton until the instrument displays **DIAG**. Make sure Lead II is selected (press LEAD SELECT if necessary).

> *Note: If the instrument does not display* **DIAG**, *make sure that the option number* **o01** *is set to 1 to enable the diagnostic mode as described beginning on page 2–8.*

5. On the 12 lead adapter, set the LIMB LEADS switch to position I (the V LEADS switch position does not matter). Confirm that the defibrillator/monitor displays a heart rate of 60 ±4bpm as listed in Table 3–4 on page 3–17. Inspect the recorder output and confirm that the recording is identical in shape and amplitude to the Lead I position shown in Figure 3–3 on page 3–18.
6. Repeat Step 5 for each of the other 11 switch settings listed in Table 3–4.
7. Set the LIMB LEADS switch to position AVL.
8. Press the SYNC pushbutton on the defibrillator/monitor. Press the ECG SIZE (▲) and the QRS VOL (▲) pushbuttons as needed until the defibrillator/monitor begins to beep indicating detection of R waves. Confirm that the defibrillator/monitor displays a heart rate of 60 ±4bpm.
9. Set the LIMB LEADS switch to position III. Confirm that the defibrillator/monitor displays a heart rate of 60 ±4bpm. Press the SYNC pushbutton to deselect synchronization.
10. Press the ECG SIZE (▲) pushbutton as needed to increase the ECG size to x4. (Press the RECORD pushbutton and examine the annotation on the printout to confirm the x4 setting, then press the RECORD pushbutton to turn off the Recorder.)

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11. Set the LIMB LEADS switch to position I. Press the RECORD pushbutton and let the Recorder print for at least 2 seconds. Change the LIMB LEADS switch to position II. Confirm that the recorded signal recovers to within 5mm of the baseline trace within 4 seconds of changing the switch.

12. Repeat Step 11 for each of the other switch settings listed in Table 3–4.

> ***Note:*** *After you complete the PIP, be sure to enter the options mode (as described on page 2–8) and reenter the user's original settings.*

Table 3–4 12 Lead ECG Adapter Switch Settings

Lead Selection	12 Lead Adapter Switch Settings		Expected Result	
	Limb Leads	V Leads	Heart Rate	Amplitude**
1. **LEAD I**	I	(n/a)*	60 ±4bpm	8 ±2mm
2. **LEAD II**	II	(n/a)*	60 ±4bpm	11 ±2mm
3. **LEAD III**	III	(n/a)*	-	4 ±2mm
4. **AVR**	AVR	(n/a)*	60 ±4bpm	9 ±2mm
5. **AVL**	AVL	(n/a)*	-	2 ±2mm
6. **AVF**	AVF	(n/a)*	60 ±4bpm	8 ±2mm
7. **V1**	V LEADS	1	60 ±4bpm	8 ±2mm
8. **V2**	V LEADS	2	60 ±4bpm	15 ±2mm
9. **V3**	V LEADS	3	60 ±4bpm	18 ±2mm
10. **V4**	V LEADS	4	60 ±4bpm	16 ±2mm
11. **V5**	V LEADS	5	60 ±4bpm	14 ±2mm
12. **V6**	V LEADS	6	60 ±4bpm	10 ±2mm

* n/a = Not Applicable (V LEADS switch may be in any position).
** ECG Size = x1.

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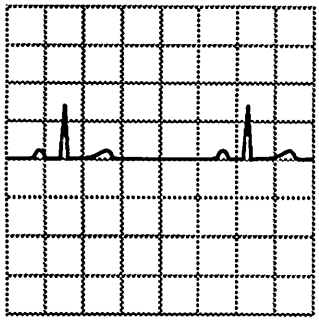
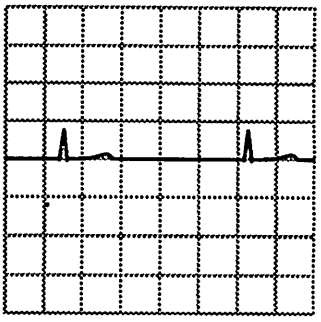
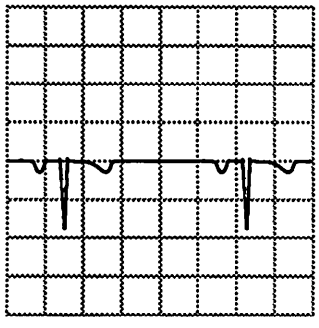


1. **Lead I** 8 ±2mm

2. **Lead II** 11 ±2mm

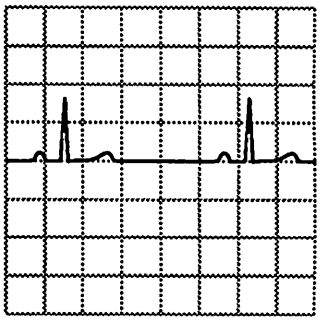


3. **Lead III** 4 ±2mm

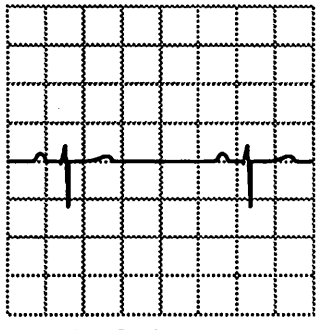


4. **AVR** 9 ±2mm

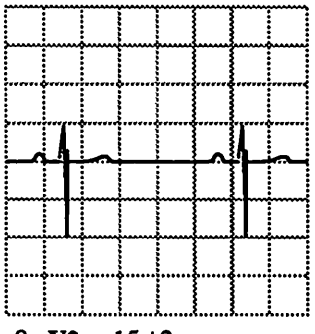
5. **AVL** 2 ±2mm



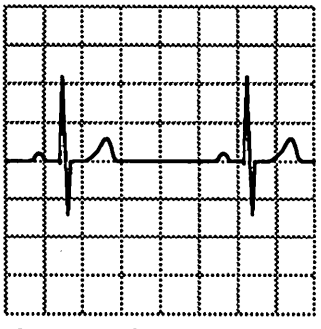
6. **AVF** 8 ±2mm



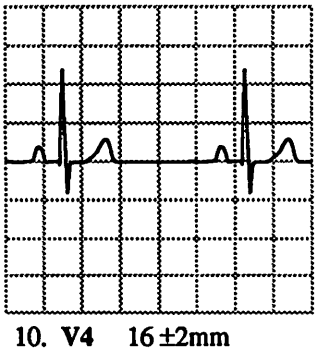
7. **V1** 8 ±2mm



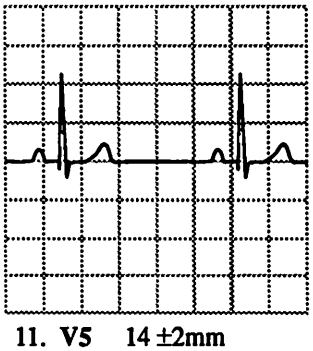
8. **V2** 15 ±2mm



9. **V3** 18 ±2mm



10. **V4** 16 ±2mm



11. **V5** 14 ±2mm

12. **V6** 10 ±2mm

Figure 3–3 Expected Recorder Outputs for 12 Lead ECG Adapter Switch Positions

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PIP Checklist

Customer: _____ Date: _____
Dept/Location: _____
Instrument Type: _____ Model: _____
Serial Number: _____
Frequency: _____ Last Insp: _____
Tech. Name/ID: _____

Performance Inspection	Pass	Fail	Comments
Physical Inspection	☐	☐	
Power-on Sequence	☐	☐	
Fault Stack Check	☐	☐	
Paper-out Sensor and Recorder Speed	☐	☐	
CODE SUMMARY	☐	☐	
Freeze and ECG Audio Checks	☐	☐	
Preamplifier Baseline Noise and CAL Pulse Checks	☐	☐	
Heart Rate and Lead Polarity	☐	☐	
Synchronized Cardioversion	☐	☐	
Warm/Cold Restart Check	☐	☐	
Pacemaker Functional Tests*	☐	☐	
Pacemaker Output Tests*	☐	☐	
Defibrillator Control and QUIK-LOOK	☐	☐	
Energy Output	☐	☐	
Refresh and Auto-Dump	☐	☐	
External Power Operation	☐	☐	
Fault Stack Recheck	☐	☐	
Leakage Current	☐	☐	
12 Lead ECG Adapter*	☐	☐	

*If option installed

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Test and Calibration Procedure

The Test and Calibration Procedure (TCP) contains in-depth testing and calibration instructions for the LIFEPAK 10 defibrillator/monitor/pacemaker. Unlike the PIP (Performance Inspection Procedure), only those tests considered necessary need to be performed, and these may be conducted in any order. It is necessary to separate the case halves for some of the tests.

TCP-Purpose and Scope

These tests may be performed if the instrument fails a step in the PIP or if there is a suspected failure in an assembly. Perform the PIP after completing any of the tests in this section.

> *Note: If you perform any of the tests in this TCP, perform the PIP (p. 3–1) afterward to confirm that the instrument is functioning within specifications.*

TCP-Applicability

This Test and Calibration procedure applies to all configurations of the LIFEPAK 10 defibrillator/monitor/pacemaker.

TCP-Definitions

ECG	Electrocardiogram
ESD	Electrical Static Discharge
MIEMSS	Maryland Institute of Emergency Medical Services Systems
NSR	Normal Sinus Rhythm
PIP	Performance Inspection Procedure
QRS or QRS Complex	Refers to portions of the ECG waveform
SSD	Static-Sensitive Device
TCP	Test and Calibration Procedure

TCP-Requirements

The following are *minimum* requirements:

TCP-Equipment Requirements

Test equipment required for maintenance and calibration of the LIFEPAK 10 defibrillator/monitor/pacemaker is listed in Table 3–5. Although specific test equipment is recommended, other test equipment with equivalent specifications may be used.

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Table 3–5 Test and Calibration Test Equipment

Equipment	Specifications	Manufacturer
Oscilloscope	Bandwidth: dc to 50MHz	Tektronix Model 2225 or equivalent*
Digital Multimeter (DMM)	3-1/2 digits Range: 0 to 1500V full scale Current range: 0 to 10A Input Resistance: 10MΩ	Fluke Model 8010 or equivalent*
High Voltage Probe	1000:1 divider, ≥20kV	Fluke Model 80K-40 or equivalent*
ECG Simulator	Amplitude: 1.0 ±0.5mV Frequency: @10Hz ±0.5Hz @60Hz ±1%	Bio-Tek QED-6 or equivalent*
Defibrillator Energy Meter	Power Range: 0-400J Load Resistance: 50Ω ±10% Accuracy: ±3%	Bio-Tek QED-6 or equivalent*
LIFEPAK 10 Programming Key		(Physio-Control PN 805144, provided with instrument)
ECG Lead Shorting Plug		(Refer to Figure 3–4)
8Ω speaker and 200Ω resistor		(For MIEMSS Modulator PCB only, refer to Figure 3–8)

* Equivalent equipment is required to meet the specifications listed in the specifications column.

TCP-Test Equipment Validation

All test equipment used in performing the TCP must have a current calibration label affixed to its exterior. The calibration label must be issued by a certified calibration facility.

TCP-Workstation Requirements

Workstations where the TCP is performed must provide an Electrical Static Discharge (ESD) protected environment. If ac line power is provided to this workstation, it must be connected to a grounded power source.

TCP-Personnel

Personnel performing this TCP must be thoroughly familiar with the operation of the LIFEPAK 10 defibrillator/monitor/pacemaker. In addition, personnel performing this TCP must meet at least one or more of the following levels of education or experience:

- Associate of applied science degree with a major emphasis in biomedical electronics
- Certificate of technical training in electronics with a major emphasis in biomedical electronics
- Equivalent biomedical electronics experience.

Warning

SHOCK HAZARD. Be sure to remove batteries and disconnect the Auxiliary Power Module (if connected) before removing the top cover.

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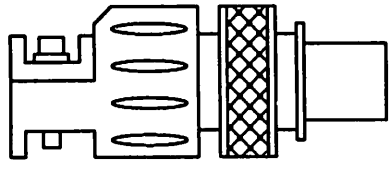
Caution — **Possible Component Damage.** Static Sensitive Devices (SSDs) require special handling. Follow the special handling procedures described on page 4–10 to prevent static discharge and damage. Refer to Table 5-1 to identify PCB assemblies containing SSDs.

Caution — **Possible Corruption of Defibrillator Constants and Options Settings.** When changing status selections or values in the options mode, after pressing CAL to enter the new value wait at least **one full second** before rotating the POWER switch to OFF to allow the System PCB microprocessor sufficient time to properly store the changes. If power is removed in less than one second, the EEROM memory contents may be corrupted, including the defibrillator calibration constants and the options mode status selections. If the EEROM memory contents are corrupted, the instrument will display the service indicator symbol indicating a failure code has been recorded. To investigate the failure, refer to Figure 2–2 (page 2–10) and Status Display Failure Codes (page 3–40). To restore the correct EEROM memory contents, reselect the proper options mode status selections and perform the Test and Calibration Procedures (TCP) for TCP-Defibrillator Calibration, TCP-AVAILABLE ENERGY Display, and TCP-Recorder Calibration (beginning on page 3–27).

TCP-System PCB Test and Calibration

The test and calibration procedures for the System PCB follow. Before beginning, confirm the instrument power is off and all batteries are removed.

Some of the following tests require that the patient connector inputs be shorted together. Using a shorting plug is one method of shorting the inputs. Construct an ECG shorting plug as shown in Figure 3–4.



6 PIN PATIENT CABLE CONNECTOR
(KEYED BETWEEN PIN A AND PIN F)
PART NUMBER 201316-000

NOTE: SHORT ALL PINS TOGETHER INSIDE BACKSHELL

Figure 3–4 ECG Shorting Plug

Refer to Figure 3–5 for potentiometer and connector locations. Refer to Figure 5-1 and Figure 5-2 (pages 5–16 and 5–17) for assistance in properly reconnecting the wires and cables when reassembling the instrument.

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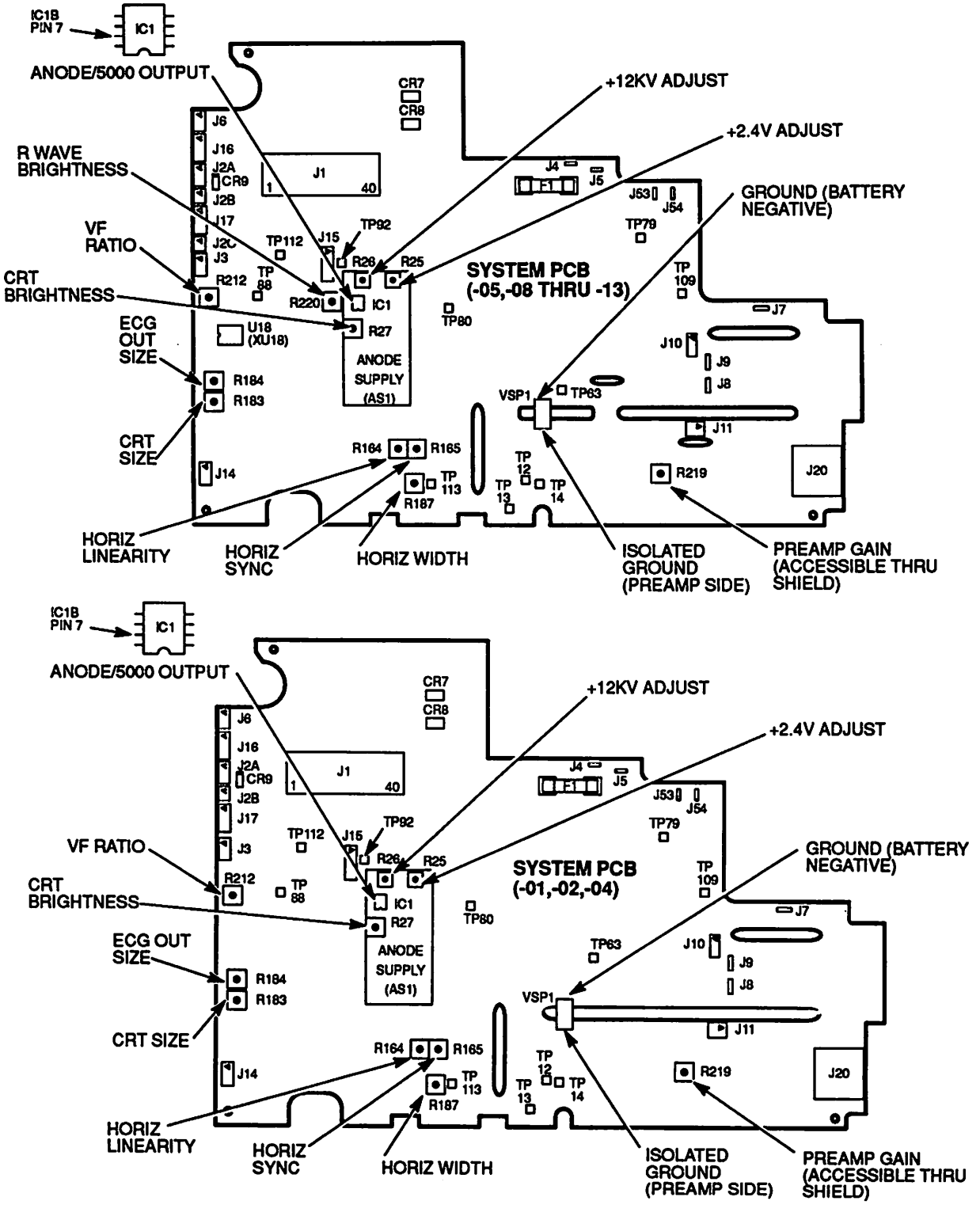

Figure 3–5 System PCB Potentiometer, Test Point, and Connector Locations

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TCP-ECG Out and Preamp Gain

Separate both case halves (refer to Case Disassembly, page 4–11). Install battery in battery receptacle 1. Insert the Programming Key into the AUX connector, rotate the Power switch to the battery 1 position, and remove the Programming Key. The instrument is now in the options mode. (For more information about the options mode, refer to Options Mode Selection and Programming, page 2–8.)

1. Make sure that option number **o10** is set to 1 to enable the output of ECG to the AUX connector.
2. Press FREEZE repeatedly until **C01** appears on the Status Display. At this point, observe three stationary "U" shapes visible on the CRT.
3. Press QRS VOL▲ until **C03** appears on the Status Display. This produces a 1Hz square wave on the CRT and activates the Recorder. Open the Recorder door to turn off the Recorder.
4. Connect an oscilloscope to pin 5 of the AUX connector using pin 6 as the ground (see Figure 3–6). If necessary, adjust R184 (ECG Out Size) for an output of 2.3 ±0.1Vp-p.

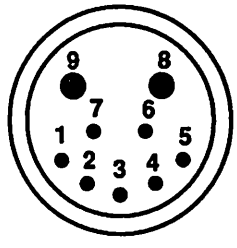

Figure 3–6 AUX Connector Pin Numbers

> *Note: These next steps describe how to adjust R219. If you have a System PCB which does not include R219, contact Physio-Control for assistance in upgrading the System PCB.*

5. Rotate the POWER switch to OFF, then to the battery 1 position. Close the Recorder door and install the ECG shorting plug, or connect the patient simulator to the patient connector with the power off. If not already in Lead **II**, press LEAD SELECT until Lead **II** displays.
6. Press the ECG SIZE (▲) pushbutton 5 times and increase ECG Size to x2.0.

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7. Press and hold RECORD for 4 seconds to select diagnostic frequency response. If the instrument does not display **DIAG**, make sure that the option number **o01** is set to **1** to enable the diagnostic mode as described beginning on page 2–8.

8. Press the CAL pushbutton repeatedly to generate pulses displayed on the CRT and printed by the Recorder.

9. Confirm that the ECG size is x2.0 (as printed along the top margin of the paper). Adjust the ECG size if necessary to obtain x2.0 and press CAL to print new pulses.

10. Confirm that the amplitudes of the pulses printed on the Recorder paper are 20 ±1mm. If necessary, adjust R219 (Preamp Gain).

> ***Note:*** *If adjustment of R219 is necessary, note that there is a 4-second delay between the time you adjust R219 and the time the change appears on the paper. Remember to press CAL to produce the pulses.*

11. Turn the Recorder off. Use the ECG simulator to input a 1mV p-p 10Hz sine wave signal to the ECG connector. Turn the Recorder on and confirm that the amplitude of the printed trace is 20 ±1mm (with "x2.0" size enabled from the previous step). If not, repeat steps 5 through 10 above. Rotate the POWER switch to OFF.

TCP-CRT Display

With the case halves separated (as described on p. 4–11, Case Disassembly), connect the patient simulator to the defibrillator patient connector. Input a 60bpm NSR signal. Adjust the potentiometers only if necessary.

1. Rotate POWER to battery 1 and select Lead II.

2. Adjust R164 (Horizontal Linearity) so that the horizontal spacing is even between each QRS complex.

3. Adjust R187 (Horizontal Width) so that the horizontal spacing between each QRS complex, as measured from the peak of the signals, is 25 ±1mm.

4. Alternate adjustment of R164 and R187 as needed to obtain evenly spaced signals 25 ±1mm.

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5. Adjust R165 (Horizontal Sync) for a stable, non-jitter display.

6. Adjust R183 (CRT Size) so that the peak of each QRS complex has an amplitude of 17 ±1mm.

7. Rotate the POWER switch to OFF.

TCP-CRT Brightness

Rotate the POWER switch to OFF and insert the Programming Key into the AUX connector. Rotate the POWER switch to the battery 1 position and remove the Programming Key. The instrument is now in the options mode.

1. Press FREEZE until **C01** displays. Then press QRS VOL (▲) so a triangle waveform appears on the CRT. In a well-lit room, adjust R27 (CRT Brightness on the Anode Power Supply; refer to Figure 3–5 on page 3–23 for the location) so the CRT trace is easily visible from five feet away, but without retrace. (Observe with the top cover down so the green filter is in front of the CRT.)

2. Rotate the POWER switch to OFF, then to the battery 1 position. Make sure that Lead II is selected. Input a 1mV, 60bpm NSR signal.

> *Note: Step 3 below is only required for System PCB revision levels which contain R220 (Part Number 804204-05 or higher). For earlier revision levels not containing R220, skip step 3.*

3. In a well-lit room, adjust R220 (R Wave Brightness) so the R wave signal brightness matches the baseline brightness from five feet away. (Observe with top cover down so the green filter is in front of the CRT.)

Caution	**Possible CRT Damage.** Excessive CRT brightness may damage the CRT.

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TCP-Modulated ECG Output

Rotate the POWER switch to OFF and insert the Programming Key into the AUX connector. Rotate the POWER switch to the battery 1 position and remove the Programming Key. The instrument is now in the options mode.

1. Select option **o10**, number **2**. Short the patient connector by using either the ECG shorting plug or connecting the patient simulator to the patient connector with the power off.
2. Connect the oscilloscope to pin 5 of the AUX connector using pin 6 as the ground (refer to Figure 3–6, page 3–24). If necessary, adjust R212 (VF Ratio) for an output of 1400 ±28Hz (714 ±14µs).
3. Reprogram the instrument for the desired auxiliary output signal.

TCP-QRS Marks

Rotate the POWER switch to OFF and insert the Programming Key into the AUX connector. Rotate the POWER switch to the battery 1 position and remove the Programming Key. The instrument is now in the options mode.

1. Select option **o10**, number **3**. Connect the oscilloscope to pin 5 of the AUX connector using pin 6 as the ground (refer to Figure 3–6, page 3–24).
2. Confirm that the output signal consists of +5 ±0.5V pulses, 1.6 ±0.2ms long, which correspond to the detected R wave.
3. Reprogram the instrument for the desired auxiliary output signal.

TCP-Defibrillator Calibration

Rotate the POWER switch to OFF, insert the Programming Key into the AUX connector, and rotate the POWER switch to the battery 1 position. Leave the Programming Key inserted for this procedure.

Warning

SHOCK HAZARD. Make sure the upper case is placed on the instrument before performing the following steps.

Press FREEZE once to enter the defibrillator calibrate mode. Confirm that **d01** and a calibration constant appear on the Status Display. The instrument is now in the options mode. Calibrate the defibrillator output energies as follows:

1. Remove the paddles from the paddle receptacles and rotate the energy select knob on the Sternum paddle to select 5J.

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Warning

SHOCK HAZARD. Keep defibrillator paddles on external energy meter at all times. Discharge the paddles into external energy meter as described.

2. Press the CHARGE pushbutton. When the defibrillator is fully charged, discharge the stored energy into the energy meter.

3. Note whether there is a difference between the selected energy and the actual energy delivered. If there is a difference, calibrate the defibrillator output using the following formula to determine the appropriate calibration factor:

$$(s - d) \times m = \text{calibration factor}$$

where selected energy = s and delivered energy = d. The multiplication factor, m, is determined from the following table:

5J	100
10J	10
20J	10
50J	10
100J	1
200J	1
300J	1
360J	1

For example, if the selected energy is 5J and the delivered energy is 4.9J, the calibration factor is calculated as:

$$(5.0 - 4.9) \times 100 = 10$$

In this example, 10 would be added to the value displayed on the Status Display. Sometimes correction factors can be negative. For example, if the selected energy is 10J and the delivered energy is 10.1J, the calibration factor is calculated as:

$$(10.0 - 10.1) \times 10 = -1$$

In this example, 1 would be *subtracted* from the value displayed on the Status Display.

4. Press the ▼ QRS VOL ▲ to adjust the value of the constant displayed on the Status Display by the amount of the calibration factor. Follow the sign of the number carefully.

5. Press CAL to enter the new display constant. Confirm that a beep tone is emitted indicating that the new value has been entered.

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6. Select a new energy level setting on the Sternum Paddle.
7. Repeat for the remaining energy settings by pressing ECG SIZE (▲) to increment the Status Display to the corresponding settings as shown below:

d02 = 10J
d03 = 20J
d04 = 50J
d05 = 100J
d06 = 200J
d07 = 300J
d08 = 360J

8. Charge to the selected energy level, then discharge into the energy meter and calculate the calibration factor.
9. Continue until all the delivered energy ranges are calibrated to within 7% of the selected value. If you change the calibration constant, be sure to recheck each energy level.

TCP-AVAILABLE ENERGY Display

You must complete the Defibrillator Calibration Test before performing this calibration of the AVAILABLE ENERGY on the Status Display. Rotate the POWER switch to OFF, insert the Programming Key into the AUX connector, and rotate the POWER switch to the battery 1 position. The instrument is now in the options mode. Press FREEZE once to obtain **d01** on the Status Display.

Warning

SHOCK HAZARD. Keep defibrillator paddles on external energy meter at all times. Discharge the paddles into external energy meter as described.

1. Rotate the energy select knob to select 5J. Press ECG SIZE (▲) to increment the Status Display to the **d11** (5J) range.
2. Charge the defibrillator and observe the internal energy meter reading on the Status Display. This calibration constant should always be 50 for the 5J range.
3. If necessary to change the calibration constant, use ▼ QRS VOL ▲ pushbuttons to select the correct value.
4. Enter the correct calibration constant by pressing CAL. Confirm that a beep tone is emitted. Discharge the stored energy into the external energy meter.

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5. For each defibrillation energy range, follow steps 1 through 4 and enter the calibration constants shown below:

Status Display Option	Energy Range	CAL Constant
d11	5J	50
d12	10J	100
d13	20J	200
d14	50J	50
d15	100J	100
d16	200J	200
d17	300J	not calibrated
d18	360J	360

Note: The 300J range does not require calibration.

6. When all calibrations are completed, turn the instrument off.

TCP-Chart/Pacer PCB Test and Calibration

The following paragraphs describe the test and calibration procedures for the Chart/Pacer PCB. Refer to Figure 3–7 for potentiometer, test point, and connector locations.

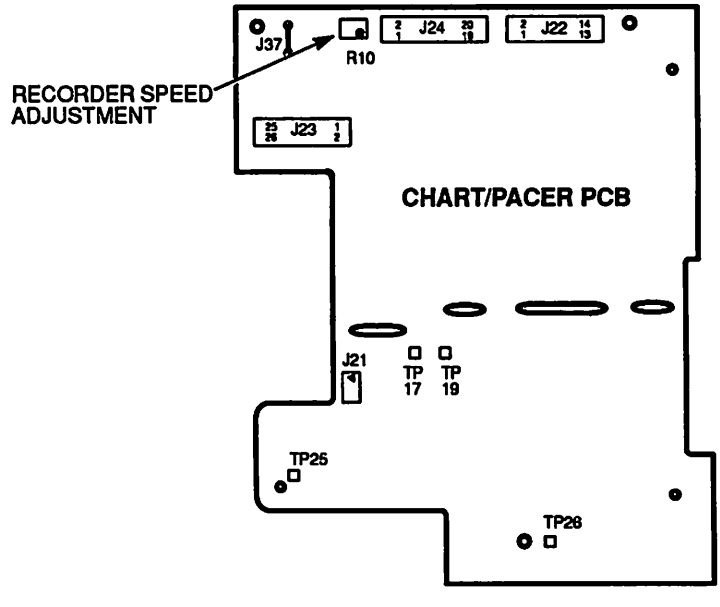

Figure 3–7 Chart/Pacer PCB Potentiometer, Test Point, and Connector Locations

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TCP-Recorder Calibration

Make sure paper is installed in the Recorder. Install the battery in the battery 2 receptacle. Rotate the POWER switch to OFF and insert the Programming Key into the AUX connector. Rotate the POWER switch to battery 2 and remove the Programming Key. The instrument is now in the options mode.

1. While the instrument is in the options mode, press and hold the RECORD pushbutton on the Main Control Panel. Confirm that the Recorder prints the entire character set and continues to do so as long as RECORD is pressed.

2. Release RECORD.

3. Press FREEZE repeatedly until the letter **A** appears on the Status Display followed by a three-digit number. Compare this number with the number printed on the Recorder printhead label. If the displayed number differs, use the QRS VOL pushbuttons (▲ or ▼) to enter the label number onto the display.

> ***Note:*** *It may be necessary to press and hold the QRS VOL pushbutton for as long as 2 seconds before the value on the display changes.*

4. With the correct number displayed, press CAL. Confirm that a beep tone sounds, indicating the displayed value has been loaded into memory.

5. Rotate the POWER switch to OFF, and then to battery 2.

> ***Note:*** *The actual stored value may not match the entered value. The software maintains a table of eight discrete resistance factors. When a resistance factor is entered during calibration, the software stores the value from its table that is closest to the entered value. Refer to Section 1, Theory of Operation, for more information.*

6. Connect the ECG leads to the ECG simulator.

7. Apply a 1mV, 60bpm NSR signal to the ECG leads input.

8. Press LEAD SELECT until Lead **II** is selected. Confirm display of the NSR waveform on the CRT. Press RECORD and confirm that a readable tracing is printed on the Recorder paper.

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9. The adjustment potentiometer for this step is located under the rubber plug in the battery 1 compartment. If necessary, adjust R10 for 25 ±1mm between R wave peaks on the Recorder.

10. Confirm that a status message is printed every 20 seconds on the upper margin of the recorder paper consisting of the following:

    (Time) (Date) Lead II X1.0 HR=60.

11. Confirm the time information is the only parameter that changes with successive messages, then press RECORD to turn off the Recorder.

TCP-Anode Power Supply Test and Calibration

Refer to Figure 3–5 on page 3–23 for the locations of the Anode Power Supply potentiometers and measurement locations.

1. Make sure a battery is installed in battery receptacle 1 and rotate the POWER switch to the battery 1 position. If the instrument has not been operating, wait at least 2 minutes to allow the CRT intensity to stabilize.

Warning

SHOCK HAZARD. Extremely high voltage (12kV) is present at the CRT anode connector (P30). Do not allow any bodily contact with the CRT anode connector or associated circuitry.

2. Using a high voltage probe connected to the DMM, measure the voltage at the CRT anode connector (P30) and confirm the voltage is 12.0 ±0.1kV. If necessary, adjust R25 to obtain the proper voltage. If adjustment of R25 is required, wait two minutes after adjusting R25, recheck the measurement, and readjust if necessary.

Note: Be sure to insert the high voltage probe tip far enough under the foam and rubber cap on the CRT anode connector to make good electrical contact with the anode connector.

3. Measure the voltage at IC1B pin 7 (the ANODE/5000 output) and confirm the voltage is +2.40 ±0.05Vdc. If necessary, adjust R26 to obtain the proper voltage.

4. Perform the TCP-CRT Display adjustment and TCP-CRT Brightness adjustment on page 3–26 to make sure the CRT brightness is properly adjusted.

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TCP-MIEMSS Modulator PCB Test and Calibration (if option is installed)

The following tests confirm the operating power and allows output calibration of the optional MIEMSS Modulator PCB. Perform the tests with the instrument case opened (as described on page 4–11, Case Disassembly) to access the MIEMSS Modulator PCB.

Warning — SHOCK HAZARD. Disconnect power before disassembling the case halves to access the MIEMSS Modulator PCB.

TCP-Frequency Calibration

1. Install a battery in the battery 1 receptacle. Rotate POWER to battery 1.
2. Connect an oscilloscope to U2 pin 4; connect to the battery negative ground on VSP1 on the System PCB (for location see Figure 3–5 on page 3–23). Install the ECG shorting plug.
3. Confirm that the output at pin 4 is a 1400 ±28Hz (714 ±14µs) triangle waveform. Adjust potentiometer R6 if necessary.

TCP-Output Gain

1. Connect the test setup as shown in Figure 3–8.
2. Confirm the following signals are audible and meet the specification listed in Table 3–6. Adjust potentiometer R9 if necessary. (The signals may also be monitored from the test setup.)

Table 3–6 MIEMSS Modulator Outputs

Location	Outputs
P2 pin 2	Triangle waveform, +200 ±20mVp-p, 1400 ±28Hz
P2 pin 3	Triangle waveform, 1.2 to 1.55Vp-p, 1400 ±28Hz
P2 pin 4	Ground

3. Connect the patient simulator to the patient input and set a 10Hz 1mV sine wave for the output. Press LEAD SELECT to display Lead II.
4. Confirm that there is a positive-going NSR signal at P2 pin 1 with an amplitude of 1.0 ±0.2Vp-p.

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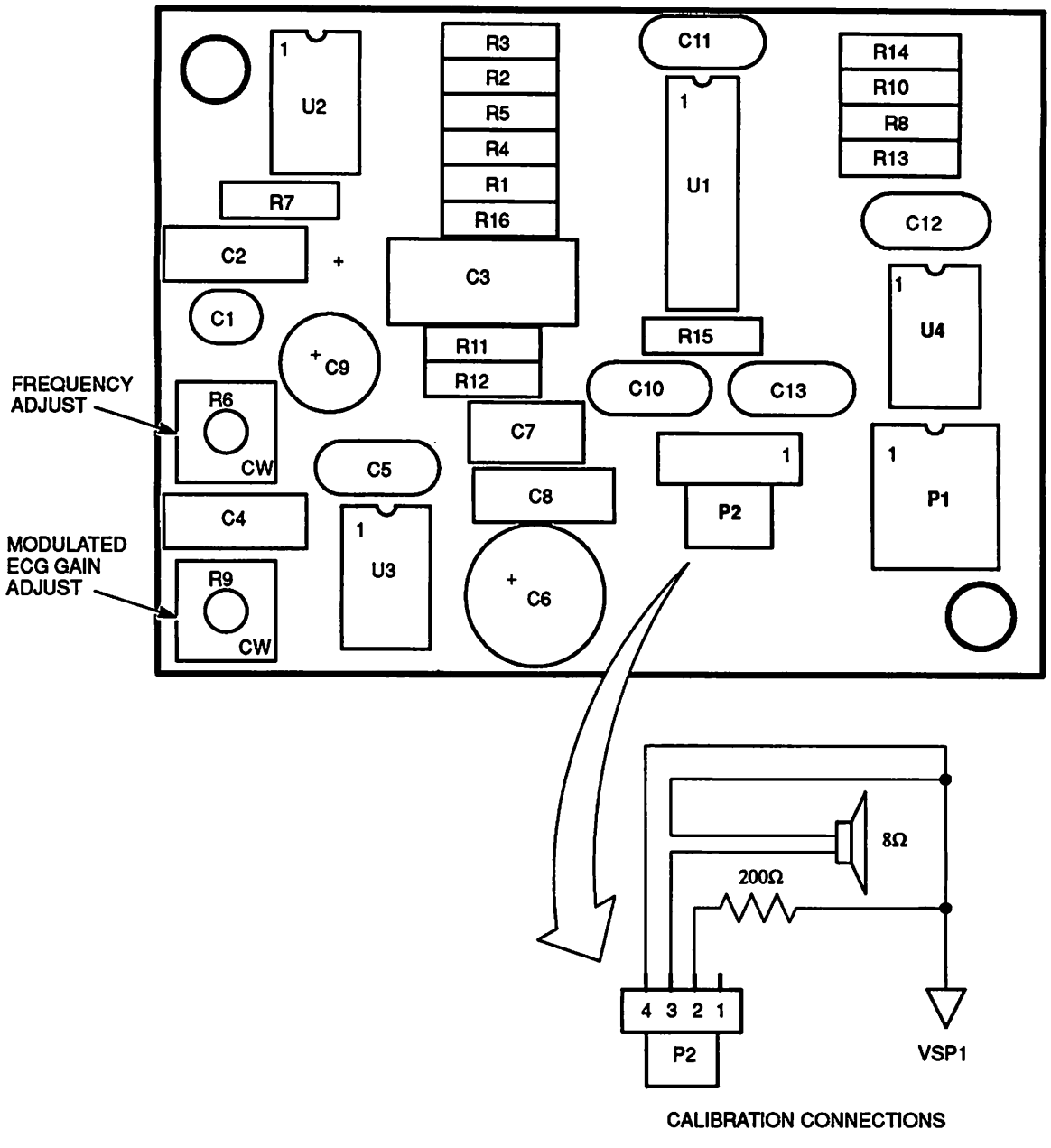

Figure 3–8 MIEMSS Calibration Setup

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TCP Checklist

Customer: _____ Date: _____
Dept/Location: _____
Instrument Type: _____ Model: _____
Serial Number: _____
Frequency: _____ Last Insp: _____
Tech. Name/ID: _____

Test and Calibration	Pass	Fail	Comments
System PCB Test and Calibration			
ECG Out/Preamp Gain	☐	☐	_____
CRT Display	☐	☐	_____
CRT Brightness	☐	☐	_____
Modulated ECG Output	☐	☐	_____
QRS Marks	☐	☐	_____
Defibrillator Calibration	☐	☐	_____
AVAILABLE ENERGY Display	☐	☐	_____
Chart/Pacer PCB Test and Calibration			
Recorder Calibration	☐	☐	_____
Anode Power Supply Test and Calibration			
	☐	☐	_____
MIEMSS Modulator PCB Test and Calibration*			
Frequency Calibration	☐	☐	_____
Output Gain	☐	☐	_____

*If Option installed

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Troubleshooting Aids

The information in this section may help a service technician isolate possible failures. It includes troubleshooting tests, Status Display Panel Failure Code descriptions, and a table to help decode the Main Control Panel Keyboard. For each procedure, use battery power unless instructed otherwise.

If an instrument failure cannot be isolated and repaired, contact a Physio-Control customer service specialist in the U.S. at 1-800-442-1142; in other countries, contact the local Physio-Control representative. While Physio-Control recommends that the instrument not be used until the failure has been resolved and the instrument passes the Performance Inspection Procedure (PIP) on page 3–1, professional discretion based on circumstance may warrant exception.

Troubleshooting Tests

The following tests provide troubleshooting assistance. The required test equipment is listed in Table 3–7. The requirements for test equipment validation, the workstation, and personnel qualifications are the same as those listed for the Test and Calibration Procedure beginning on page 3–20.

Table 3–7 Test Equipment Required for Troubleshooting

Equipment	Specifications	Manufacturer
DC Power Supply	Output Voltage: 0 to 20Vdc Output Current: 0 to 3A	Topward Model TPS 2000 or equivalent*
Digital Multimeter (DMM)	3-1/2 digits Range: 0 to 1500V full scale Current range: 0 to 10A Input Resistance: 10MΩ	Fluke Model 8010 or equivalent*
Defibrillator Analyzer	Power Range: 0-400J Load Resistance: 50Ω ±10% Accuracy: ±3% Waveform Playback Capacity	Bio-Tek QED-6 or equivalent*

* Equivalent equipment is required to meet the specifications listed in the specifications column.

Warning

SHOCK HAZARD. Be sure to remove batteries and disconnect the Auxiliary Power Module (if connected) before removing the top cover of the defibrillator/monitor/pacemaker.

Caution

Possible Component Damage. Static Sensitive Devices (SSDs) require special handling. Follow the special handling procedures described on page 4–10 to prevent build-up of static charge. Refer to Table 5–1 on page 5–3 to identify PCB assemblies containing SSDs.

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Power-Up and Power-Down Tests

Make sure that power is off to the defibrillator/monitor/pacemaker and the dc power supply. Turn on power to the dc power supply, set the power to +12V, then turn the power off. Connect the dc power supply and a DMM in series with the battery 1 terminals. Observe proper polarity as indicated near the battery terminal posts. Turn on power to the power supply and adjust the power supply output to +12.0 ±0.1Vdc.

Caution	**Possible Equipment Damage.** Power-up current exceeds 2A. Use the 10A current range on the DMM.

1. Rotate the POWER switch to the battery 1 position.
2. Confirm that the stabilized current draw from the battery is less than 1A.
3. Confirm that the stabilized current draw from the battery with the Recorder running is less than 1.2A.
4. Confirm the instrument performs a display test and powers-up in the Lead II or paddles configuration (this is a programmable selection; refer to page 2–8, Options Mode Selection and Programming).
5. Confirm the CRT display brightness is acceptable after warm-up (15 seconds).
6. Turn the instrument off and remove the DMM from the circuit and reconnect the power supply to battery 1 terminal.

Power Supply Voltage Checks

Use the negative battery terminal as the ground for the DMM and measure the voltages at the locations listed in Table 3–8. Refer to Figure 3–5 on page 3–23 for the test point locations.

Table 3–8 System PCB Power Supply Voltage Checks

Test Point Location	Nominal DC Voltage
tab of CR8	+15.0 ±1.0V
TP109	–15.0 ±1.5V
tab of CR7	+18.0 ±1.8V
TP112	–25.0 ±2.0V
TP113	+5.0 ±0.5V

(continued on next page)

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Test Point Location	Nominal DC Voltage
TP80	+2.40 ±0.05V
TP92	+6.0 ±0.3V
TP79	+5.0 ±1.0V
TP63	+2.5 ±1.0V
TP88	+2.5 ±1.0V
Note: To check these preamplifier voltages, connect the DMM to the isolated ground connection accessible on the preamp side of VSP1 (refer to Figure 3–5 on page 3–23 for VSP1 location).	
TP13	+16.0 ±1.5V
TP14	–16.0 ±1.5V
TP12	+5.0 ±0.1V

+12V Power Monitor Check

This test checks the low battery and power off voltage thresholds.

1. With the external power supply connected to the battery 1 receptacle, reduce the power supply output to a voltage between +10.2V and +9.7V.
2. Confirm that three beeps sound and the battery 1 low battery indicator flashes.
3. Reduce the dc power supply input to +8V and confirm the instrument powers down.
4. Increase the dc power supply voltage input to +12V. Confirm the instrument powers on and the battery 1 LED illuminates steadily.
5. Repeat steps 2 through 4 for battery receptacles 2 and 3.

Output Waveform

This test checks the defibrillator output waveform.

1. Connect the patient cable to the defibrillator analyzer.
2. Place a battery in receptacle 1 and rotate the POWER switch to battery 1.
3. Rotate the ENERGY selection switch to 360J and press CHARGE. Confirm that the instrument reaches its fully-charged state in less than 10 seconds.

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4. Confirm that a rising tone is audible during the charge cycle, and a steady tone sounds when charging is complete.
5. Discharge the stored energy into the defibrillator analyzer.
6. Transfer the stored energy waveform from the defibrillator analyzer to the defibrillator and so that it prints on the defibrillator Recorder paper.
7. Confirm that the defibrillator output waveform approximately matches the waveform in Figure 3–9.

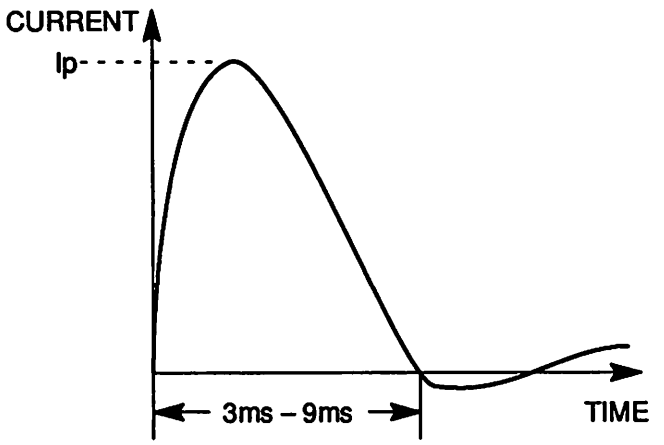

Figure 3–9 Defibrillator Output Waveform

Pacemaker Voltage Checks

The following test points are more easily located from the top of the Chart/Pacer PCB.

1. Turn the instrument POWER switch to OFF and make sure a battery is installed in the battery 1 receptacle.
2. Remove the instrument top cover. Detach the Chart/Pacer PCB by removing the three stand-offs that attach the Chart/Pacer PCB to the upper case (refer to page 4–11 for detailed disassembly instructions). Lower the PCB onto an anti-static pad to prevent shorting out the components on the underside.
3. Rotate the POWER switch to battery 1 and press the PACER pushbutton to turn on the pacemaker.

Warning

SHOCK HAZARD. High voltage of +350Vdc is present at TP25 and associated circuitry. Do not allow any bodily contact with the Chart/Pacer Isolated Power Supply circuitry.

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4. Use isolated ground (accessible at TP24) and measure the following voltages. Refer to Figure 3–7 on page 3–30 for the test point locations.

TP25	350 ±35Vdc
TP17	12.0 ±1.0Vdc
TP26	5.0 ±0.1Vdc
TP19	6.9 ±0.4Vdc

MIEMSS Modulator PCB Supply Voltages

1. Make sure a battery is installed in battery receptacle 1 and rotate the POWER switch to battery 1.
2. Connect the DMM ground to P2 pin 4. Check that the following voltages are within tolerance. Refer to Figure 3–8 on page 3–34 for the connection locations.

U4 pin 8	+15.0 ±1.5Vdc
U4 pin 4	–15.0 ±1.5Vdc
U4 pin 5	+2.50 ±0.25Vdc

Status Display Failure Codes

Table 3–9 lists possible causes for some instrument failures along with the codes associated with each failure. These codes appear on the Status Display. Refer to Options Mode Selection Flow Chart, Figure 2–2 on page 2–10, for instructions on selecting failure code data while in the options mode.

Table 3–9 Status Display (Fault Stack) Failure Codes

Failure Code	Description	Possible Cause Of Failure Code
1	System microcomputer ROM failure	System microcomputer (U15)
2	System microcomputer RAM failure	System microcomputer (U15)
3	Not used	
4	Abnormal transfer occurred (not necessarily a recent failure)	a. Open air discharge b. Transfer drive circuitry
5	Pacemaker hardware failure	a. +12V or +320V pacemaker power supply b. Current delivery c. Fault sense circuitry d. Chart/Pacer microcomputer (U8)
6	Defib/ECG microcomputer (U20) self-test error	a. Defib/ECG microcomputer (U20) RAM or ROM error b. System Microcomputer (U15) c. Serial data error

(continued on next page)

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Table 3–9 Status Display (Fault Stack) Failure Codes

Failure Code	Description	Possible Cause Of Failure Code
6 (cont.)	Preamp test failure	a. Preamp hybrid (U41) b. Preamp power supply c. Lead select analog switch d. Optical coupler e. Any preamp component that would corrupt a CAL pulse
7	Energy ready compare error	a. One of the high voltage dividers out-of-tolerance b. Charge Control hybrid (U24) c. Auxiliary A/D (U9) or voltage reference d. Defib/ECG microcomputer (U20) e. System microcomputer (U15) f. Serial data error
8	System watchdog error	a. Defib/ECG microcomputer (U20) b. System microcomputer (U15)
9	A/D Converter failure	A/D Converter (U9)
10	+6.67V supply out-of-tolerance	a. Excessive load on any supply b. PWM Controller (U1) c. R3 or R9 out-of-tolerance
11	+15V supply out-of-tolerance	a. Excessive load on any supply b. PWM Controller (U1) c. R3 or R9 out-of-tolerance
12	Anode supply out-of-tolerance	a. Anode Power Supply b. Jumper on AS1 Shutdown (pin 5) c. Voltage at TP80 out-of-tolerance
13	Transfer drive circuitry failure	Q26, Q27, Q13, or CR17
14*	EEROM failure	EEROM, U10 failure
15	Defib/ECG microcomputer (U20) serial data error	Defib/ECG microcomputer (U20)
16	Pacemaker serial data error	Chart/Pacer microcomputer (U8)

**If this error occurs after a new PCB has been installed, perform TCP-Defibrillator Calibration, TCP-AVAILABLE ENERGY Display, and TCP-Recorder Calibration (beginning on page 3–27); then clear the error code, perform the PIP, and check to see if the error code is gone.*

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Main Control Panel Keyboard Decoding

The following information is provided as an aid to troubleshooting. Table 3–10 shows the keyboard layout and the meaning of the row-column contact closures. Key closures can be simulated by momentarily connecting the indicated connector positions. For example, FREEZE can be simulated by connecting J1-37 to J1-33. The ECG SIZE and QRS VOLUME controls will scroll if contact is maintained. Use an oscilloscope to determine whether the following conditions exist:

- Only one of the row signals is active at a time. The signals are "active-high."
- Column signals appear with the appropriate contact closure and coincide with the appropriate row activation.

Table 3–10 Main Control Panel Keyboard Matrix

Columns		0 (J1-35)	1 (J1-37)	2 (J1-39)	3 (J1-40)
Rows	0 (J1-32)	QRS VOL ▼	QRS VOL ▲	ECG SIZE ▲	ECG SIZE ▼
	1 (J1-31)	CODE SUMMARY	CAL	LEAD SELECT	
	2 (J1-33)	RECORD	FREEZE	SYNC	

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Service and Maintenance 4

Introduction

This section provides the following information:

- Battery Maintenance
- Battery Connector Pin Maintenance
- Recorder Maintenance
- Special Handling Procedures for Static Sensitive Devices
- Disassembly Procedures
- Inspection Techniques
- Tools and Materials for Cleaning and Repair
- Cleaning Procedures
- PCB Repair Precautions
- Preparation for Storage or Shipping

Before servicing or repairing the instrument: become familiar with this section; perform a close visual examination (see the section on Inspection Techniques on page 4–18); use the information in Section 5 to aid in identifying components, assemblies, and wire and cable harnesses.

Battery Maintenance

The LIFEPAK 10 defibrillator/monitor/pacemaker uses Nickel-Cadmium (Ni-Cd) batteries. These Ni-Cd batteries must be properly maintained using the Battery Support System to maximize battery life and performance.

Ni-Cd Battery Performance Factors

Three major factors which affect the performance of Ni-Cd batteries are as follows:

- Temperature
- Voltage Depression
- Self-Discharge Rate.

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Temperature

Charging a battery at temperatures below 20°C (68°F) or above 25.5°C (78°F) will prevent the battery from reaching its full capacity and may lead to *irreversible* cell damage.

Voltage Depression

Voltage depression is a condition which reduces battery performance, particularly when charging the defibrillator. This condition is often mistakenly called memory. Voltage depression can usually be reversed by reconditioning the battery every 3 months as described on page 4–4. Voltage depression is caused by:

- Repeatedly attempting to add more charge to a fully charged or a nearly fully charged battery
- Extended charging at temperatures above the maximum recommended 25.5°C (78°F).

Warning

POSSIBLE POWER FAILURE. Using a battery affected by voltage depression may result in power failure during patient care without warning. Be sure to properly maintain batteries as described in this section.

Self-Discharge Rate

Like most batteries, Ni-Cd batteries self-discharge when they are not used. A new Ni-Cd battery self-discharges approximately 1% of its capacity each day when stored at room temperature. In ten days a new Ni-Cd battery not installed in the defibrillator/monitor loses approximately 10% of its capacity. The self-discharge rate of the battery can be evaluated by performing a Shelf-Life Test. The actual battery self-discharge rate depends on:

- Battery age
- Temperature
- Frequency of use
- Length of time in storage
- Physical battery condition.

These factors can combine to increase the battery discharge rate. For example, an older battery stored in higher temperatures may have an accelerated self-discharge rate much greater than 1% a day.

Caution

Possible Battery Damage. Remove and replace a battery when the low battery indicator light begins flashing. Over-discharging can shorten battery life.

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Physio-Control Ni-Cd Batteries

Use only Physio-Control batteries and battery chargers with Physio-Control instruments. Use only the Physio-Control Battery Support System for battery maintenance.

Warning

POSSIBLE INSTRUMENT FAILURE. Physio-Control has no information regarding the performance or effectiveness of its LIFEPAK defibrillators/monitors/pacemakers if they are used in conjunction with remanufactured or alternate source batteries or chargers from other sources. Use only Physio-Control batteries and chargers.

Any one of the Physio-Control FASTPAK, LIFEPAK 5 FASTPAK, or LIFEPAK 5 Battery Pak batteries can power the LIFEPAK 10 defibrillator/monitor/pacemaker. The batteries require different charge times:

- FASTPAK batteries charge in the Battery Support System in approximately 70 minutes.
- The Battery Pak battery charges in the Battery Support System in approximately 4 1/2 hours.

Use Only the Battery Support System to Maintain Batteries

To properly maintain batteries, use the Battery Support System along with the following guidelines (each guideline is detailed beginning on page 4–4):

- Charge batteries at the proper temperature
- Place the Battery Support System in a proper location
- Rotate batteries
- Recondition batteries every three months
- Perform Shelf Life Test every six months.

Use only the Battery Support System to maintain the FASTPAK, LIFEPAK 5 FASTPAK, and LIFEPAK 5 Battery Pak Ni-Cd batteries.

Warning

POSSIBLE BATTERY DAMAGE. The two-well Battery Charger (Physio-Control Part Numbers 9-00284, 9-00288, and 801530) is not designed to charge FASTPAK batteries. Charging the FASTPAK battery in the two-well standard Battery Charger may reduce battery life and create a risk of fire or explosion. Do not charge the FASTPAK battery in the standard Battery Charger.

The older two-well standard Battery Charger should not be used for maintenance. This older Battery Charger *does not* perform all the tests required to properly evaluate battery performance.

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Warning

POSSIBLE INSTRUMENT FAILURE. The AC and DC Auxiliary Power Modules do not maintain batteries. Use only the Battery Support System to maintain batteries. The AC and DC Auxiliary Power Modules do not replace the Battery Support System.

The primary use of the AC and DC Auxiliary Power Modules is to supply external power to operate the instrument. Both Power Modules trickle-charge batteries within 24 hours, but will not perform all the procedures required to properly maintain or evaluate battery performance. For further details, refer to the Operating Instructions and Service Manual included with each Power Module.

Charge Batteries at the Proper Temperature

The optimum charging temperature is room temperature, or 20° to 25.5°C (68° to 78°F). Batteries charged outside room temperature may not reach full capacity even if the charge time is increased. This may lead to *irreversible* cell damage.

Place the Battery Support System in a Proper Location

Use the following guidelines for location of the Battery Support System:

- Place in a well-ventilated area
- Keep at room temperature
- Do not place in direct sunlight
- Do not place near a heat source or an air conditioner.

Rotate Batteries

Rotate batteries so that all batteries in active service are used equally.

Recondition Batteries Every Three Months

Reconditioning a battery helps prevent or reverse the effects of voltage depression and helps keep track of battery capacity. Reconditioning is a succession of discharge/charge cycles performed in the Battery Support System. Perform reconditioning *every three months* according to Table 4–1. Discard any battery with a capacity reading of less than 80% on the third cycle.

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Table 4–1 Reconditioning Procedure

Step	Description	Capacity/Result
1	CHARGE battery until READY light appears	
2	Cycle #1; DISCHG–CHARGE–READY	disregard reading
3	Cycle #2: DISCHG–CHARGE–READY	disregard reading
4	Remove battery for 1-4 hours Begin:_____ End:_____	
5	Cycle #3: DISCHG–CHARGE–READY	bat. capacity = _____%*
6	Log Cycle #3 Bat. cap % on back of battery *80% or greater Acceptable Less than 80% Unacceptable (Discard Battery)	

Perform Shelf Life Test Every Six Months

The Shelf Life Test evaluates the self-discharge rate of a stored battery. Perform the Shelf Life Test in Table 4–2 *every six months, or alternate it with the Reconditioning Procedure in Table 4–1 every three months.* Discard any battery with a Shelf Life Test value of more than 20.

Table 4–2 Shelf Life Test Procedure

Step	Description	Capacity/Result
1	Charge battery until READY light appears	
2	Cycle #1: DISCHG–CHARGE–READY	disregard reading
3	Cycle #2: DISCHG–CHARGE–READY	disregard reading
4	Remove battery for 1-4 hours Begin:_____ End:_____	
5	Cycle #3: DISCHG–CHARGE–READY	bat. capacity = _____%
6	Log Cycle #3 battery capacity % on back of battery (Steps 1-6 are the same as Reconditioning Procedure)	
7	Remove battery and store on a shelf for 7 to 8 days Begin:_____ End:_____	
8	Cycle #4: DISCHG–CHARGE–READY	subtract bat. capacity = _____%
9	Shelf Life Test Value* *20 or less Acceptable More than 20 Unacceptable (Discard Battery)	**Test Value** = _____*

Receiving New Batteries

When receiving newly purchased batteries, promptly label and recondition each one.

Label Batteries

Label each new FASTPAK or Battery Pak with a unique identification number so that it can be easily tracked through all maintenance and rotation.

Recondition New Batteries

Because Ni-Cd batteries self-discharge, a new battery may not be fully charged by the time it is received. Recondition a newly purchased battery according to Table 4–1 .

Storing Batteries

Store batteries in the Battery Support System or on a shelf. Even in storage, batteries require routine maintenance.

When storing on a shelf, store at the proper temperature.

- Store batteries between 4.4° and 26.7°C (40° and 80°F). Cooler temperatures reduce the battery self-discharge rate.
- Never freeze batteries.

Warning

POSSIBLE INSTRUMENT FAILURE. Failure to charge a stored battery before returning it to active service may result in premature power failure of the monitor or defibrillator during patient care. Always charge a stored battery *before returning it to active service.*

Discarding Batteries

When properly maintained, the Physio-Control FASTPAK and Battery Pak Ni-Cd batteries should have a battery life of approximately two years. Discard a battery in an environmentally safe manner if any of the following circumstances occur:

- Less than 80% of the battery capacity remains *after* reconditioning,
  or
- There is a difference of *greater than 20* after performing a battery Shelf Life Test,
  or
- There is physical damage to the battery case,
  or
- The Battery Support System indicates that the battery is faulty.

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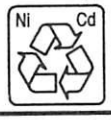
Recycling Batteries

Recycle discarded Ni-Cd batteries locally according to national, state, and local regulations. If local recycling is not possible, in the U.S. contact Physio-Control customer service specialists at 1-800-442-1142. In other countries contact your local Physio-Control representative.

> ***Note:*** *Physio-Control batteries manufactured after July 1991 are labeled with recycle symbol.* 
>

Installing and Removing a Battery

To install the battery, proceed as follows:

1. Align the battery with the battery well so that the battery clip is toward the pins.
2. Lower the front end of the battery (opposite the battery clip) into the battery well.
3. Lower the clip end of the battery into the battery well and press until a click is heard.

To remove the battery, press the battery clip and lift.

Battery Connector Pin Maintenance

As a part of routine preventive maintenance, inspect the battery connector pins (Physio-Control Part Number 802278-02) and replace any pins which appear bent, broken, loose, corroded, worn, or damaged. Inspection of the battery connector pins is included as part of the Performance Inspection Procedure (PIP-Physical Inspection) on page 3–4.

The pins may be replaced without opening the case. Use a 5/32-inch nut driver to unscrew the threaded shaft and remove the pin as shown in Figure 4–1. When installing a pin, make sure the threads are properly aligned. Tighten the pin firmly, but do not overtighten.

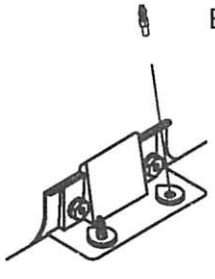


Figure 4–1 Battery Connector Pin Replacement

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Recorder Maintenance

This section provides general maintenance information for the Recorder used in this instrument. A mechanical illustration and list of parts are shown in Figure 5–3 on page 5–19. Refer to this figure to locate parts specified in these procedures. To protect Recorder paper and recordings follow these guidelines:

- Do not apply tape or other adhesives over annotation or ECG tracing. Adhesives may be applied to the back of the paper.
- Store paper only in paper folders. Do not store in plastic folders.
- Avoid extended exposure to sunlight. Avoid temperatures over 27°C (80°F) and relative humidity over 70%.

Printhead Cleaning

Clean the printhead periodically to prevent paper debris from collecting on the printhead surface. Perform cleaning after using approximately 100 rolls of chart paper or more often if needed. Clean the printhead with a cotton swab that has been soaked in clean isopropyl alcohol.

1. Switch the instrument power off. Locate the printhead (refer to Figure 5–3 on page 5–19, Recorder Assembly). The printhead is positioned between the two brushes on the upper half of the Recorder.

2. Wipe the surface of the printhead clean with the alcohol-soaked cotton swab, taking care to allow only the cotton tip of the swab to make contact with the printhead.

Recorder Paper Sensor Cleaning

The paper sensor also requires periodic cleaning to prevent paper debris from blocking the infrared signals that reflect off the paper during normal operation. Refer to Figure 4–2 for the location of the paper sensor.

Clean the sensor whenever the printhead is cleaned. Use a clean cotton swab soaked in clean isopropyl alcohol. Gently wipe the surface of the paper sensor with the tip of the swab.

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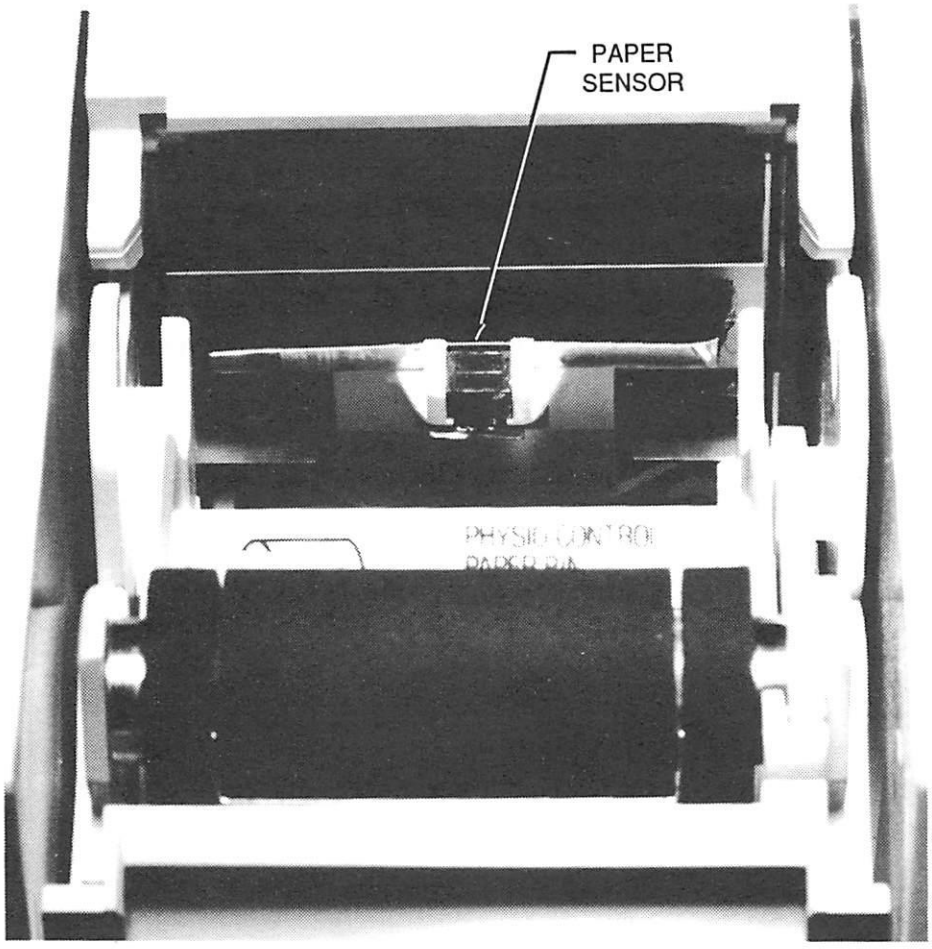

Figure 4–2 Recorder Paper Sensor Location

Recorder Paper Replacement

Caution	**Possible Printhead Damage.** Use only Physio-Control paper (Part Number 804700) for Thermal Array Recorders. Do not use waxed papers.

1. Make sure Recorder power is off. Pull up the slot-textured door of the Recorder to expose the paper roll.
2. Remove empty paper roll.
3. Replace with new roll of recorder paper (with the paper grid facing toward the front).
4. Pull out a short length of paper and close the doors of the Recorder (rear door first).

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Special Handling Procedures For Static Sensitive Devices

Many electronic semiconductor devices such as MOS ICs, FETs, optical isolators, or film resistors can be damaged by the discharge of static electricity. It is very common for anyone to build up static charges, especially when wearing synthetic clothes, and to transfer this charge to any object touched. Such a discharge can damage or destroy Static Sensitive Devices (SSDs). In most cases, the discharge is not even perceptible to the person at fault.

In order to prevent damage to SSDs due to static discharge, observe the following precautions when performing any open-case test, maintenance, or repair procedures:

Look for SSD Symbol

Note that SSDs such as PCBs are indicated in this service manual with the following warning:

Use Static-Dissipative Mat

Always perform repair or maintenance on a static-dissipative mat connected to earth ground.

Wear Wrist Strap

Always wear a conductive wrist strap connected to the mat and to ground except when working on energized equipment or when discharging high voltage circuits. The strap must be snug enough to make good contact against bare skin.

Warning

SHOCK HAZARD. Remove the wrist strap when working on energized equipment or when discharging high voltage circuits.

Transport and Store PCBs Properly

Transport and store PCBs in anti-static racks or inside conductive bags. Label the package containing the PCBs as static-sensitive.

Keep Work Area Static-Free

Keep static-generating products such as styrofoam cups or trays away from the work area. Connect all electrical equipment such as soldering irons and test equipment to ground through a three-prong plug.

Test Work Area Routinely

Test all the anti-static parts of the work area (mat, straps, cables) routinely. Keep a log of the test results.

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Disassembly Procedures

The following procedures provide a logical sequence for disassembling the major components of LIFEPAK 10 defibrillator/monitor/pacemaker. Separate or disassemble only to the extent required. Parenthetical numbers refer to item numbers in the Final Assembly Parts List and Figure 5–1 (page 5–16). Each "P" connector mates to a "J" connector with the same number. Reassembly procedures are the reverse unless otherwise noted.

Warning

SHOCK HAZARD. Disconnect Battery Pak and Battery Charger before performing the disassembly procedures.

Caution

Possible PCB Damage. Some PCB assemblies in the instrument contain Static Sensitive Devices (SSDs). Use SSD handling procedures as described on page 4–10.

Note: Three types of the screws used in the assembly of the defibrillator/monitor/pacemaker (items 67, 68, 70 on the Final Assembly Parts List and Figure 5–1 on page 5–16) have plastic coatings on the threads to help secure the screws. These screws are intended to be used only once. Whenever these screws are removed, they should be discarded and replaced.

Case Disassembly

Place the LIFEPAK 10 defibrillator/monitor/pacemaker upside down on the work surface.

1. Remove the 16 screws (70) that are accessible from the bottom of the instrument. (Discard these screws and replace when reassembling.)
2. Turn the entire instrument right side up, holding the case shut with both hands, with the carrying handle facing the front of the work surface.
3. Carefully lift the Upper Case Enclosure (12) straight up, until it clears the top of the CRT screen. When the Upper Case Enclosure is clear of obstructions, tilt it back and rest it on its rear panel.

System PCB Removal

Warning

SHOCK HAZARD. Make sure the defibrillator storage capacitor (C1) is fully discharged before removing the System PCB.

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Caution **Possible PCB Assembly Damage.** The System PCB requires special SSD handling procedures as described on page 4–10.

Note: Since the options mode settings are stored in EEROM, if you replace the System PCB (which contains the EEROM) you will lose the current options mode settings. Before removing a System PCB for replacement, be sure to enter the options mode (as described on page 2–8) and write down the user's current options mode settings. After installing the new System PCB, be sure to enter the options mode and reenter these recorded settings.

1. Refer to Figure 4–3 and Figure 5-2 (page 5–17) for connector locations and unplug the quick disconnect connectors from the System PCB. If necessary, use small pliers to help remove the following connectors:

P4 and P5	Battery Connections
P53 and P54	Paddle Cable Shields
P7	Charge Output Wire Harness (W3)
P8 and P9	Transfer Relay Drive

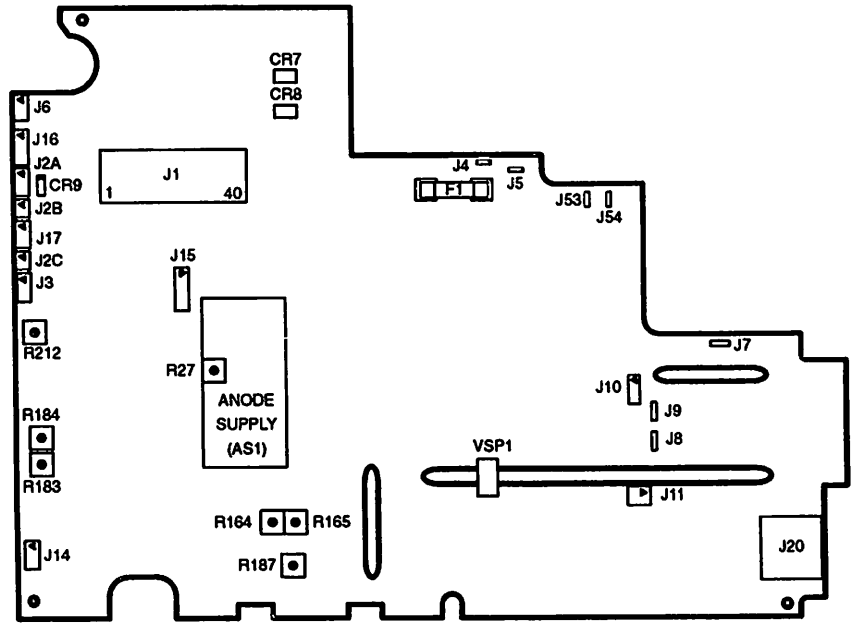

Figure 4–3 System PCB Connector Locations

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2. Refer to Figure 4–3 and Figure 5-2 (page 5–17) and remove the following locking connectors from the System PCB:

P11	QUIK-LOOK Paddles Wire Harness (W5)
P10	Relay Wire Harness (W6)
P1	Ribbon Cable to Chart/Pacer PCB
P2A,B and C	Auxiliary Connector
P3	Battery Switch
P6	Speaker Harness
P16 and P17	Paddle Assemblies

3. Use snap–ring pliers to unscrew the black plastic nut (45) securing the patient ECG connector. Remove the O–ring seal (73) and slide up the ECG connector retainer (61) to free the ECG flex assembly at J20.

4. Remove the single screw (68) securing the System PCB to the lower case located between the ECG input connector and the preamp shield. (Discard this screw and replace it when reassembling.)

5. Grasp the CRT (A11) by its rubber front mount, and lift it and the left side of the System PCB slightly. Slide the entire System PCB/CRT assembly to the left and away from the lower case.

CRT Removal

1. Remove the two screws (69) securing the rear CRT mount to the System PCB (the screws are 67 and 69 if the MIEMSS PCB is installed; discard screw 67 and replace it when reassembling).

2. Disconnect the deflection yoke connector at J14 (see Figure 4–3) from the System PCB.

3. Pull the CRT PFC Assembly (A12) out from under the top of the rubber CRT front mount (40), so that the exposed metal of A12 is accessible.

4. Insert a small flat-blade screwdriver under the CRT anode insulator and make contact with the anode connector.

5. Use a clip-lead jumper to discharge the CRT anode through the screwdriver to the CRT flex.

6. Disconnect the CRT anode connector by inserting a small flat-blade screwdriver under the anode insulator. Make firm contact with the metal of the CRT connector, and pry gently until it pulls loose. Do not try to remove the anode connector by pulling on the high voltage wire.

7. Remove the bracket supporting the CRT yoke and gently pull the CRT base connector straight off.

8. Peel off the rubber CRT front mount, and pull the CRT loose.

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Storage Capacitor Removal

Warning — **SHOCK HAZARD.** Make sure the defibrillator storage capacitor (C1) is fully discharged before removing it.

1. Lift the waveshaping inductor (L1) out of its compartment, and set it on top of the Relay Assembly (A10).
2. Remove the two quick disconnect connectors from the storage capacitor (C1) terminals.
3. Cut the two large tie wraps (59) securing the storage capacitor to the lower case. Also cut the small tie wrap that captures the battery wires to J4 and J5.
4. Lift out the storage capacitor.

Relay Removal

1. Remove the four screws (68) securing the Relay Assembly (A10) to the lower case. (Discard these screws and replace them when reassembling.)
2. Cut the two tie wraps at the front of the Relay Assembly that capture some of the wires to the lower case.

Note: Each wire connection to the Relay Assembly is permanently marked with a number that corresponds to its counterpart stamped on the body of the relay assembly. These numbers must match when reconnecting the relay assembly to the wire harness.

Chart/Pacer PCB Removal

Warning — **SHOCK HAZARD.** Potentially lethal voltages may be present at the front left corner of the Chart/Pacer PCB. Short the series combination of R110 and R113 with a wire jumper prior to handling the Chart/Pacer PCB.

Caution — **Possible PCB Assembly Damage.** The System PCB requires special SSD handling procedures as described on page 4–10.

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1. Remove the three plastic standoffs (88) that secure the Chart/Pacer PCB (A2) to the Upper Case Enclosure (12).

2. Disconnect the pacemaker output harness at J21 (see Figure 4–4), and fold the Chart/Pacer PCB flat for servicing. Use an appropriate anti-static insulator pad under the Chart/Pacer PCB to protect it from breakage and static electricity.

3. Remove remaining connectors J22, J23, J24 (see Figure 4–4), and quick disconnect ground connector J37 to remove the Chart/Pacer PCB.

> ***Note:*** *Be sure to remove the wire jumper across R110 and R113 when reassembling the Chart/Pacer PCB.*

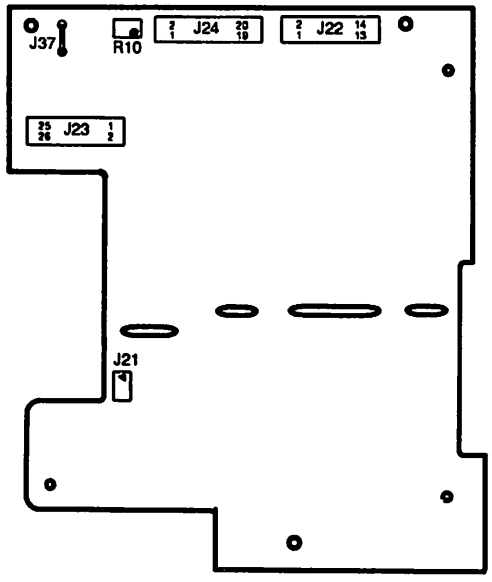

Figure 4–4 Chart/Pacer PCB Connector Locations

Optional MIEMSS Modulator PCB Removal

1. Cut the tie wrap (58) around W15.

2. Disconnect W15 and W16 from the MIEMSS Modulator PCB.

3. Remove two screws (67) and remove the PCB. (Discard these screws and replace them when reassembling.)

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Main Control Panel Removal

1. Remove the five screws (68) securing the keypad to the Upper Case Enclosure (12). (Discard these screws and replace them when reassembling.)
2. Remove the single locking connector P27 to complete panel removal.

Status Display Module Removal

After removing the Chart/Pacer PCB (A2), proceed with removal of the Status Display Module Assembly (A9).

1. Loosen the two screws (68) retaining the Status Display Module Assembly and slide it out from behind the front panel. (Discard these screws and replace them when reassembling.)
2. Disconnect connector P28 and remove the module.

Pacer Control/Battery Indicator Panel Removal

After removing the Chart/Pacer PCB (A2), proceed with removal of the Pacer Control/Battery Indicator Panel (A5).

1. Remove the auxiliary power input line to the POWER switch (90) (quick disconnect labeled A located in the top position or "12 o'clock" position on the POWER switch).
2. Remove the five screws (68) securing the Pacer Control/Battery Indicator Panel to the Upper Case Enclosure (12). (Discard these screws and replace them when reassembling.) The panel then will fold out and to the left.
3. Disconnect P26 and cut the tie wrap that retains the pacemaker cable to remove the module.

Battery Switch Removal

1. Use padded pliers to remove the POWER knob (18) by grasping firmly and pulling gently.
2. Remove the battery switch mounting nut.
3. Pull the POWER switch (90) through from the inside. Make a diagram of the locations of the quick disconnect wire terminals for reinstallation and remove them.

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Paddles Removal

After removing the Chart/Pacer PCB (A2), proceed with removal of the Paddles Assembly (A8).

1. Disconnect the paddle control wires from the System PCB (A1) by disconnecting J16 and J17 (see Figure 4–3, page 4–12).
2. Cut tie wraps as necessary to isolate the paddle harnesses.
3. Remove high voltage quick disconnects P49 and P51 from the relay mount (41) .
4. Remove paddle cable shield connectors at J53 and J54 from the System PCB.
5. Remove wires from wire retainer (65) on Upper Case Enclosure.
6. Pry out the coil cord retainer (60) at the paddles strain relief.
7. Push the paddles strain relief through to the outside of the instrument to remove the paddles. Refer to Figure 5-4 , Paddle Assembly (page 5–22), to aid in further disassembly.

Recorder Assembly Removal

The Recorder Assembly (A7) may be removed without case disassembly. Open the Recorder door and remove the two screws (70) visible in the bottom of the Recorder. (Discard these screws and replace them when reassembling.) Lift up assembly slightly, pull it toward the rear, and lift it up and out of its case well. Refer to Figure 5–3, Recorder Assembly (page 5–19), to aid in further disassembly.

Upper Case Enclosure Replacement

> ***Note:*** *Upper Case Enclosure replacement requires that these assemblies be removed first: Chart/Pacer PCB, Main Control Panel, Status Display Module, Pacer Control Panel, Battery Switch, Paddles, and Recorder Assembly.*

To isolate the Upper Case Enclosure (12), it is necessary to remove the auxiliary connector (part of wire harness W7). This is accomplished by removing the retaining nut (44) on the inside of the case. The pacer output connector (37) and harness cannot be removed without damage to the connector, and must be replaced with the Upper Case Enclosure.

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Front Paddle Retainer Replacement

The Front Paddle Retainer (63) is normally welded to the Upper Case Enclosure (12). Should the Front Paddle Retainer separate from the Upper Case Enclosure, it may be reattached or replaced using the following steps:

1. Sand or file the original weld area so that the textured part of the Front Paddle Retainer fits flush with the top surface of the Upper Case Enclosure.
2. If the Front Paddle Retainer is a new replacement part, sand or file down the raised plastic ridges (weld area) flush with the surrounding surface.
3. Apply a small amount of Sicomet 77 cyanoacrylate adhesive (Part Number 201754-005) in an oval pattern on the inside vertical surface of the Front Paddle Retainer.
4. Place the Front Paddle Retainer against the Upper Case Enclosure and apply direct pressure for 30 seconds. Do not stress or disturb the bond for 30 minutes.

Inspection Techniques

When servicing or repairing the instrument, begin with a visual inspection. If damage is found, look for other peripheral damage.

Exterior Inspection

Visually inspect the entire instrument for wear, corrosion, deterioration, and damage resulting from extreme temperatures, dropping, or other abuse. Lift and turn the instrument upside down while listening for loose hardware.

Interior Inspection

Table 4–3 lists the major hardware components of the instrument, possible problems, and recommended corrective actions.

Table 4–3 Inspection Techniques

Hardware	Problem	Corrective Action
Chassis, covers, and brackets	Warped, bent, damaged surface, or missing hardware	Replace
Components (mechanical and electrical)	Loose mountings Broken, or damaged leads Deterioration or leakage	Repair Replace Replace
Connector pins	Slightly bent Badly bent, loose or corroded	Straighten Replace
Battery connector pins	Bent, broken, loose, corroded, worn	Replace pin (see page 4–7).

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Hardware	Problem	Corrective Action
Nameplate, labels, and decals	Illegible	Replace if damaged
PCB surfaces	Charred, cracked, or brittle	Replace PCB
	Note: *Some discoloration of the PCB surface can be expected due to high operating temperatures of some components.*	
Screws and nuts	Loose or cross-threaded	Tighten or replace
Terminals and connections	Improperly installed Missing or worn Failed solder connections	Install correctly Replace Resolder (if not damaged) or replace
Wire insulation and tubing	Deteriorated, worn, pinched, or damaged	Replace

Tools and Materials for Cleaning and Repair

Table 4–4 lists recommended tools, materials, and chemicals required for cleaning and repair. Although specific items are recommended in Table 4–4, other tools and materials with specifications equivalent to those listed may be used.

Table 4–4 Tools and Materials for Cleaning and Repair

Product	Description
Static-protected work area Electronic Supply Dealers	Grounded conductive surface and wrist strap
X-32B and Xersin® solder Multicore Westbury, NY 11590	Low flux, no cleaning necessary
5-Minute® Epoxy Devcon Danvers, MA 01923	Adhesive
Tak Pak® Loctite Newington, CT 06111	Adhesive and 710 accelerator
Crocus cloth	
Isopropyl alcohol	
Acid brush	
Cotton swabs	
Vacuum cleaner	
Soft-bristle brush	Nonmetallic
Cloth	Clean and lint-free
Compressed air	Clean and dry (60psi, max.)

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Cleaning Procedures

Clean the instrument as needed during maintenance or after disassembly and repair.

Exterior Cleaning

Clean the instrument case and cables with mild soap and water.

Warning

SHOCK OR FIRE HAZARD. Do not immerse any portion of the instrument in water. Fluid spills and splashes will damage the instrument's electrical components.

Caution

Possible Equipment Damage. Do not use solvents, alcohol, or abrasive agents on the instrument surface.

Caution

Do Not Autoclave the Instrument.

Interior Cleaning

Follow disassembly procedures (beginning on page 4–11) to access instrument interior.

Warning

PERSONAL SAFETY HAZARD. Ventilate work area when using isopropyl alcohol to avoid possible inhalation of harmful vapors. Observe manufacturer warnings regarding personal safety and emergency first aid. Keep first aid equipment available.

Warning

CHEMICAL FIRE HAZARD. Observe shop safety and fire precautions. Store isopropyl alcohol and alcohol-soaked rags in approved containers. Refer to manufacturers instructions on containers for recommended firefighting procedures. Keep firefighting equipment available.

Caution

Possible Component Damage. Use SSD handling procedures when working on static sensitive devices (SSDs).

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Caution — **Possible Component Damage.** Do not use chemicals or solvents to clean transformers or inductors; to do so may remove varnish from the wire coils rendering the component useless. Solvents neutralize adhesives resulting in tape separation from the windings.

1. Brush surfaces and parts with a nonmetallic soft-bristle brush. Remove loosened dirt and dust using dry low-pressure compressed air (60psi) or a vacuum cleaner.

2. Wipe metal surfaces with a soft, nonabrasive cloth dampened with isopropyl alcohol.

Caution — **Possible Nameplate Damage.** Do not use abrasive cleaners or solvents to wipe nameplates and labels—the nameplate information may disappear.

3. Wipe surfaces of nameplates and labels with a clean, dry cloth.

Caution — **Possible Component Damage.** Do not use solvents to clean plastic parts.

4. Clean surfaces of plastic parts with a mild soap and water solution. Dry with a clean cloth.

5. Clean soldering surfaces with a nonmetallic, soft-bristle brush dipped in alcohol then wipe with absorbent cloth. Air dry 10 minutes or use low-pressure compressed air (60psi) before soldering.

PCB Repair Precautions

The LIFEPAK 10 defibrillator/monitor/pacemaker uses double-sided PCBs, multilayer PCBs and printed flex circuits.

Caution — **Possible PCB damage.** Improper handing can easily damage the PCBs beyond repair. Plated-through holes connecting the circuitry on two sides of the PCB can be damaged by too much heat.

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> *Note:* *Before attempting any PCB repair, contact Physio-Control. Customer PCB repair may endanger any applicable PCB exchange agreement or other warranty.*

Multilayered PCBs are not easily repaired. They consist of alternate layers of conductive patterns and insulating material bonded together and interconnected with plated-through holes. The internal layers and connection points are quickly damaged by too much heat, rendering the entire PCB useless. Therefore, it is recommended that all multilayer PCBs such as the System PCB and Chart/Pacer PCB be returned to Physio-Control for repair or replacement. Also, do not attempt to repair the CRT PFC.

Preparation for Storage or Shipping

Save the original shipping box and packing material for later use when shipping the instrument.

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Parts Lists and Schematics 5

Introduction

This section includes parts lists, component layouts or exploded views, and schematic diagrams for each major assembly of the LIFEPAK 10 defibrillator/monitor/pacemaker. Table 5–1 lists the figure and page number of the major assemblies. Table 5–2 is a key for reference designator abbreviations. Table 5–3 lists supplies and accessories.

Parts List

Use parts lists to identify *replaceable* parts. The format for each list is the same:

Ref: This column contains the reference designators or the assigned item numbers of replaceable parts. Reference designators are abbreviated (see Table 5-2) and are listed alphanumerically by this abbreviation. Assigned item numbers are listed numerically, starting with 2. The number in the heading of this column indicates the figure to which the parts list corresponds.

Part Number: Physio-Control Corporation part number is listed in this column. Part ordering information is provided on page 5-2.

Description: Descriptive information for a part that is used more than once refers to the initial listing with a "Same as ___" citation. This citation may also list a component value when necessary.

Static Sensitive Devices (SSDs) are identified in this column by this symbol:

For information about proper handling of SSDs during repair or replacement, refer to page 4–10.

Use Code: Different hardware configurations and their corresponding letter codes are listed at the beginning of each parts list. Subsequent use of any letter code indicates which part is used in a particular configuration. A blank in this column indicates that the part is used in all configurations.

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Qty: The quantity column specifies the *total* quantity used for each part number listed. The abbreviation REF indicates a major assembly or subassembly.

Component Layouts or Exploded Views

Use component layouts or exploded views to physically locate parts. The reference designator or assigned item number on the drawing corresponds to the REF column entry on the parts list.

Schematic Diagrams

Schematic diagrams show circuit function and signal flow. Signal names, pin numbers, and polarities are labeled as well as reference designators and values from the parts list.

- In general, signal flow is from left to right
- Circuit names on schematics match descriptions in Section 1
- ICs marked with a ✻ are detailed in Section 6
- To/From labels correspond to connections shown on the interconnect diagram.

Part Ordering

When ordering from Physio-Control Corporation in the U.S., call the toll free PARTSLINE number (1-800-442-1142). Give the instrument part number and serial number located on the bottom panel of your instrument. Then specify all assembly numbers, part numbers, reference designations, and descriptions. Different parts may be substituted by Physio-Control to reflect instrument modifications and improvements. To order parts in other countries, contact your local Physio-Control representative.

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Table 5–1 Major Assemblies

Ref	Part Number	Nomenclature	Fig. No.	Page No.
	804200	LIFEPAK 10 defibrillator/monitor/pacemaker Final Assembly	5–1	5–16
		Interconnect Diagram	5–2	5–17
A1	804204	System PCB Assembly ⚠	5–7	5–41
A2	804202	Chart/Pacer PCB Assembly ⚠	5–8	5–58
A3	804296	Anode Power Supply ⚠	5–10	5–66
A4	804277	Main Control Panel Assembly	5–11	5–67
A5	804196	Pacer Control/Battery Indicator Panel Assembly	5–12	5–68
A6	804258	Energy Select PCB Assembly	5–13	5–70
A7	804189	Recorder Assembly, GSI ⚠	5–3	5–19
A8	804250	Paddle Assembly	5–4	5–22
A9	805230	Status Display Module ⚠	5–5	5–23
A10	800240	Relay Assembly	5–6	5–24
A11	805180	CRT Assembly	5–14	5–71
A12	805078	CRT PFC Assembly	5–15	5–72
A13	805115	Harnesses	----	
A14	------	Chassis	----	
A15	805608	MIEMSS Modulator PCB Assembly	5–9	5–64
W1	805115-01	Capacitor Negative-Relay Wire Harness	5–16	5–73
W2	805115-02	Capacitor Positive-Relay Wire Harness	5–17	5–73
W3	805115-00	Charger Output Wire Harness	5–18	5–74
W4	805115-14	Inductor/Relay Wire Harness	5–19	5–75
W5	805115-03	QUIK-LOOK, Apex, Sternum Wire Harness	5–20	5–76
W6	805115-04	System PCB-Relay Wire Harness	5–21	5–77
W7	805115-15	Auxiliary Power Connector-System PCB Wire Harness	5–22	5–78
W8	805115-09	Battery-Chart/Pacer PCB Wire Harness	5–23	5–79
W9	805115-10	Battery-Battery Switch-System PCB Wire Harness	5–24	5–80
W10	805115-07	Battery Switch-System PCB Wire Harness	5–25	5–81
W11	805115-06	Speaker-System PCB Wire Harness	5–26	5–81
W12	804249-00	Pacer Cable	5–27	5–82
W13	804252-01	Control Cable	5–28	5–83
W14	804253-00	Recorder Cable	5–29	5–84
W15	805628-00	System PCB-MIEMSS PCB Cable	5–30	5–85
W16	805629-01	MIEMSS PCB Output Cable	5–31	5–86
	805600	12 Lead ECG Adapter	5–32	5–88

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Table 5–2 Reference Designator Key

Reference Designator	Description
A	Main Assemblies
C	Capacitor
CR	Diode
F	Fuse
J	PCB-mounted Jack Connector
K	Relay
L	Inductor
P	Cable-mounted Plug Connector
Q	Transistors
R	Resistor
RN	Resistor Network
RV	Varistor
S	Switch
T	Transformer
TP	Test Point
U	IC (integrated circuit)
VSP	Voltage Surge Protector
W	Wire Harness
Y	Crystal

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Supplies and Accessories

Supplies and accessories for the LIFEPAK 10 defibrillator/monitor/pacemaker are listed in Table 5–3. The Physio-Control part number is listed for each item. To order an item from Physio-Control in the U.S., call the Physio-Control PARTSLINE at 1-800-442-1142. In other countries contact your local Physio-Control representative.

Table 5–3 Supplies and Accessories

Description/Quantity	Part Number
Auxiliary Power Module	
120 or 220Vac input	804217
12Vdc input	804220
Battery Support System	801807
For recharging FASTPAK batteries	
Cable	
Pacing Cable	802905
Patient Cable (3 lead, AHA)	9-10418
Patient Cable (3 lead, IEC)	800947
DERMA JEL Electrode Jelly	
Twelve 4oz tubes	9-10236-012
Electrodes:	
FAST-PATCH disposable defibrillation/ECG electrodes:	
1 set (2 electrodes)	804545-001
10 sets (20 electrodes)	804545-010
50 sets (100 electrodes)	804545-050
LIFE•PATCH Pre-Gelled Adult ECG Electrodes:	
Box of 30 electrodes (10 pkgs/box)	800139-030
Case of 300 (10 boxes/case)	800139-300
QUIK-PACE Pacing Electrodes:	
1 set (2 electrodes)	803377-101*
5 sets (10 electrodes)	803377-501*
25 sets (50 electrodes)	803377-251*
**Do not substitute disposable defibrillation electrodes or ECG electrodes for pacing electrodes. Use only Physio-Control pacing electrodes for pacing.*	
FASTPAK battery (1 battery)	9-10424-09

(continued on next page)

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Table 5–3 Supplies and Accessories (continued)

Description/Quantity	Part Number
FAST-PATCH adapter	805094
12-lead ECG adaptor	805600
External Pediatric Paddle Attachment	
1 each (2 required)	800418
QUIK TEST cable tester	805550
Programming Key	805144
Recorder Paper (each roll 50mm x 30m/100ft):	
Box of 3 rolls	804700-003
Case of 150 rolls (50 boxes)	804700-150
Soft Carrying Case	805155
Operating Instructions	805057
Service Manual	804271
Booklet: *Noninvasive Pacing: What You Should Know*	805074
Booklet: *Defibrillation: What You Should Know*	805662
Video (for inservice training) VHS 1/2in format	805156

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5-1 Ref	Part Number	Description	Use Code	Qty
		LIFEPAK 10 defibrillator/monitor/pacemaker		
	804200-00	With Pacing, English	A	REF
	804200-01	With Pacing, German	B	REF
	804200-02	With Pacing, French	C	REF
	804200-03	With Pacing, Spanish	D	REF
	804200-04	With Pacing, English, International	E	REF
	804200-05	Without Pacing, English	F	REF
	804200-06	Without Pacing, German	G	REF
	804200-07	Without Pacing, French	H	REF
	804200-08	Without Pacing, Spanish	I	REF
	804200-09	Without Pacing, English, International	J	REF
	804200-10	With Pacing, English, CSA	K	REF
	804200-11	Without Pacing, English, CSA	L	REF
	804200-12	With Pacing, French, CSA	M	REF
	804200-13	Without Pacing, French, CSA	N	REF
	804200-14	With Pacing, English	O	REF
	804200-15	With Pacing, German	P	REF
	804200-16	With Pacing, French	Q	REF
	804200-17	With Pacing, Spanish	R	REF
	804200-18	With Pacing, English, International	S	REF
	804200-19	Without Pacing, English	T	REF
	804200-20	Without Pacing, German	U	REF
	804200-21	Without Pacing, French	V	REF
	804200-22	Without Pacing, Spanish	W	REF
	804200-23	Without Pacing, English, International	X	REF
	804200-24	With Pacing, English, CSA	Y	REF
	804200-25	Without Pacing, English, CSA	Z	REF
	804200-26	With Pacing, French, CSA	AA	REF
	804200-27	Without Pacing, French, CSA	AB	REF
	804200-28	With Pacing, English	AC	REF
	804200-29	With Pacing, German	AD	REF
		LIFEPAK 10 defibrillator/monitor/pacemaker		
	804200-30	With Pacing, French	AE	REF
	804200-31	With Pacing, Spanish	AF	REF

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5-1 Ref	Part Number	Description (continued from previous page)	Use Code	Qty
	804200-32	With Pacing, English, International	AG	REF
	804200-33	Without Pacing, English	AH	REF
	804200-34	Without Pacing, German	AI	REF
	804200-35	Without Pacing, French	AJ	REF
	804200-36	Without Pacing, Spanish	AK	REF
	804200-37	Without Pacing, English, International	AL	REF
	804200-38	With Pacing, English, CSA	AM	REF
	804200-39	Without Pacing, English, CSA	AN	REF
	804200-40	With Pacing, French, CSA	AO	REF
	804200-41	Without Pacing, French, CSA	AP	REF
	804200-42	Without Pacing, English, MIEMSS	AQ	REF
	804200-43	Without Pacing, English, Military	AR	REF
	804200-44	With Pacing, English, International, NEMKO	AS	REF
	804200-45	With Pacing, English, Outside US	AT	REF
	804200-46	Without Pacing, English, Outside US	AU	REF
A1	804204-01	System PCB Assembly ▲2	A-N	1
	804204-02	System PCB Assembly ▲2	O-AB	1
	804204-04	System PCB Assembly ▲2	O-AB	1
	804204-05	System PCB Assembly ▲2	O-AB	1
	804204-08	System PCB Assembly ▲2		1
	804204-09	System PCB Assembly ▲2		1
	804204-10	System PCB Assembly ▲2		1
	804204-11	System PCB Assembly ▲2		1
	804204-12	System PCB Assembly ▲2		1
	804204-13	System PCB Assembly ▲2		1
	804204-14	System PCB Assembly ▲2	AQ	1
	804204-15	System PCB Assembly ▲2	AC-AP,AR-AU	1
A2	804202-02	Chart/Pacer PCB Assembly ▲2	A-E,K,M	1
	804202-03	Chart/Pacer PCB Assembly ▲2	F-J,L,N	1
	804202-04	Chart/Pacer PCB Assembly ▲2	O-S,Y,AA	1
	804202-05	Chart/Pacer PCB Assembly ▲2	T-X,Z,AB	1
	804202-06	Chart/Pacer PCB Assembly ▲2	O-S,Y,AA	1

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5-1 Ref	Part Number	Description (continued from previous page)	Use Code	Qty
	804202-07	Chart/Pacer PCB Assembly ⚠2	T-X,Z,AB	1
	804202-08	Chart/Pacer PCB Assembly ⚠2	O-S,Y,AA	1
	804202-09	Chart/Pacer PCB Assembly ⚠2	T-X,Z,AB	1
	804202-12	Chart/Pacer PCB Assembly ⚠2	AC-AG,AM,AO,AS,AT	1
	804202-13	Chart/Pacer PCB Assembly ⚠2	AH-AL,AN,AP,AQ,AR,AU	1
A3	804296-03	Anode Power Supply Assembly ⚠2	A-N	1
	804296-05	Anode Power Supply Assembly ⚠2	O-AU	1
A4	804277-01	Main Control Panel Assembly, French	C,H,M,N,Q,V,AA,AB,AE,AJ,AO,AP	1
	804277-02	Main Control Panel Assembly, German	B,G,P,U,AD,AI	1
	804277-03	Main Control Panel Assembly, Spanish	D,I,R,W,AF,AK	1
	804277-04	Main Control Panel Assembly, English	A,E,F,J-L,O,S,T,X-Z,AC,AG,AH, AL-AN,AQ-AU	1
A5	804196-01	Battery Indicator Assembly (No Pacer)	F-J,L,N,T-X,Z,AB,AH-AL,AN,AP-AR, AU	1
	804196-05	Pacer Control Panel Assembly	A,K,O,Y,AC,AM,AT	1
	804196-06	Pacer Control Panel Assembly, French	C,M,Q,AA,AE,AD,AO	1
	804196-07	Pacer Control Panel Assembly, German	B,P,AD	1
	804196-08	Pacer Control Panel Assembly, Spanish	D,R,AF	1
	804196-09	Pacer Control Panel Assembly, International	E,S,AG,AS	1
A6	804258-02	Energy Select PCB Assembly (Not shown, part of Sternum Paddle Assembly)		1
A7	804189-00	Recorder Assembly		1
A8	804250-00	Paddle Assembly, Apex	A-N	1
	804250-06	Paddle Assembly, Apex	O-AR,AT,AU	1
	804250-08	Paddle Assembly, Apex, NEMKO	AS	1
	804250-05	Paddle Assembly, Sternum	A-AR,AT,AU	1
	804250-07	Paddle Assembly, Sternum, NEMKO	AS	1
A9	805230-01	Status Display Module, LCD, Backlit ⚠2		1
A10	800240-12	Relay Assembly (Not Repairable)		1
A11	805180-00	CRT Assembly		1
A12	805078-01	CRT PFC Assembly		1
A15	805608-01	MIEMSS Modulator PCB Assembly	AQ	1
C1	804285-02	Capacitor, Energy Storage		1

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5-1 Ref	Part Number	Description (continued from previous page)	Use Code	Qty
W1	805115-01	Capacitor Negative-Relay Wire Harness		1
W2	805115-02	Capacitor Positive-Relay Wire Harness		1
W3	805115-00	Charger Output Wire Harness		1
W4	805115-05	Inductor-Relay Wire Harness	A-N	1
	805115-14	Inductor-Relay Wire Harness	O-AU	1
W5	805115-03	QUIK-LOOK Apex and Sternum Wire Harness		1
W6	805115-04	System PCB-Relay High Voltage Wire Harness		1
W7	805115-13	Auxiliary Power Connector-System PCB Wire Harness	A-AB	1
	805115-15	Auxiliary Power Connector-System PCB Wire Harness	AC-AU	
W8	805115-09	Battery-Chart/Pacer PCB Wire Harness		1
W9	805115-10	Battery-Battery Switch-System PCB Wire Harness		1
W10	805115-07	Battery Switch-System PCB Wire Harness		1
W11	805115-06	Speaker-System PCB Wire Harness		1
W12	804249-00	Pacer Cable		1
W13	804252-01	Control Cable		1
W14	804253-00	Recorder Cable		1
W15	805628-00	System PCB-MIEMSS Modulator PCB Cable	AQ	1
W16	805629-01	MIEMSS Output Cable	AQ	1
2	804240-01	**Ball**		1
3	9-10424-09	**Battery**, Fastpak		A/R
4	804297-01	**Bezel**, Main, Control Panel		1
5	805072-02	**Bezel**, Pacer, Control Panel	A-E,K,M,O-S,Y,AA,AC-AG,AM,AO,AS, AT	1
6	805072-01	**Bezel**, Pacer, Cover (Not shown)	F-J,L,N,T-X,Z,AB,AH-AL,AN,AP-AR, AU	1
7	805631-00	**Bracket**, Mounting, Lower	AQ	1
8	805632-00	**Bracket**, Mounting, Upper	AQ	1
9	804194-00	**Cover**, Cap Mount		2
10	802278-02	**Connector**, Plug, Banana, Mini, No Solder, 0.218 L (Used on J31-36)		6
11	804191-04	**Enclosure**, Lower Case		1
12	804190-08	**Enclosure**, Upper Case	A-AP,AR,AS,AU	1
	804190-09	**Enclosure**, Upper Case, MIEMSS	AQ	1

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5-1 Ref	Part Number	Description (continued from previous page)	Use Code	Qty
13	802885-00	**Foot,** Mounting		4
14	804206-01	**Grommet,** Battery Post		6
15	804235-01	**Heat Sink,** Vertical Deflection		1
16	805122-03	**Housing,** Pacing Connector, Plug, White	F-J,L,N,T-X,Z,AB,AH-AL,AN,AP-AR, AU	1
17	202196-000	**Insulator,** Transistor, White, #2015-54		1
18	804229-09	**Knob,** Battery Switch, With Insert		1
19	804261-02	**Label,** Auxiliary Power Connector, Domestic	A,F,O,T,AC,AH,AQ,AR,AT,AU	1
	804261-03	**Label,** Auxiliary Power Connector, International	B-E,G-N,P-S,U-AB,AD-AG,AI-AP,AS	1
20	803785-00	**Label,** Canadian Standards	AM-AP	1
21	805335-00	**Label,** Warning, Electrical Hazard	AG,AL,AS	1
22	804266-02	**Label,** Warning, Shock, Domestic	A,F,O,T,AC,AH,AQ,AR,AT,AU	1
	804266-01	**Label,** Caution, Shock, International	B-E,G-N,P-S,U-AB,AD-AG,AI-AP,AS	1
23	805027-00	**Label,** ECG Connector, English	A,E,F,J-LO,S,T,X-Z,AC,AG,AH,AL-AN, AQ-AU	1
	805027-01	**Label,** ECG Connector, French	C,H,M,NQ,V,AA,AB,AE,AJ,AO,AP	1
	805027-02	**Label,** ECG Connector, German	B,G,P,U,A,D,AD,AI	1
	805027-03	**Label,** ECG Connector, Spanish	D,I,R,W,AF,AK	1
24	804446-00	**Label,** Pacer LED Cover	AC-AG,AM,AO,AS,AT	2
25	805017-05	**Label,** Pacing Connector, English	A,O,AC,AT	1
	805017-06	**Label,** Pacing Connector, English, International	E,K,S,Y,AG,AM,AS	1
	805017-07	**Label,** Pacing Connector, French	C,M,Q,AA,AE,AO	1
	805017-08	**Label,** Pacing Connector, German	B,P,AD	1
	805017-09	**Label,** Pacing Connector, Spanish	D,R,AF	1
26	804193-08	**Label,** Display Panel	A,E,F,J-LO,S,T,X-Z,AC,AG,AH,AL-AN, AQ-AU	1
	804193-09	**Label,** Display Panel, French	C,H,M,NQ,V,AA,AB,AE,AG,AJ,AO,AP	1
	804193-10	**Label,** Display Panel, German	B,G,P,U,AD,AI	1
	804193-11	**Label,** Display Panel, Spanish	D,I,R,W,AF,AK	1
27	805633-00	**Label,** Internal Moduiation Option	AQ	1
28	805018-12	**Label,** Operating Instructions, English	AC,AG,AH,AL,AM,AN,AQ-AU	1
	805018-13	**Label,** Operating Instructions, French	AE,AJ,AO,AP	1
	805018-14	**Label,** Operating Instructions, German	AD, AI	1
	805018-15	**Label,** Operating Instructions, Spanish	AF,AK	1

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5-1 Ref	Part Number	Description (continued from previous page)	Use Code	Qty
29	804264-04	Label, Power Select, English	A,F,K,L,Q,T,Y,Z,AC,AE,AH,AM,AN,AQ, AR,AT,AU	1
	804264-05	Label, Power Select, French	C,H,M,N,Q,V,AA,AB,AE,AJ,AO,AP	1
	804264-06	Label, Power Select, German	B,G,P,U,AD,AI	1
	804264-07	Label, Power Select, Spanish	D,I,R,W,AF,AK	1
	804264-08	Label, Power Select, English, International	E,J,S,X,AG,AL,AS	1
30	804267-02	Label, Paddle, Apex		1
31	804268-08	Label, Paddle, Sternum, English	A,E,F,J-L,O,S,T,X-Z,AC,AG,AH, AL-AN,AQ-AU	1
	804268-09	Label, Paddle, Sternum, French	C,H,M,N,Q,V,AA,AB,AE,AJ,AO,AP	1
	804268-10	Label, Paddle, Sternum, German	B,G,P,U,AD,AI	1
	804268-11	Label, Paddle, Sternum, Spanish	D,I,R,W,AF,AK	1
32		Label, Serial Number		
	804260-12	With Pacing, With Information, English	A,K,O,Y	1
	804260-27	With Pacing, With Information, German	B,P	1
	804260-14	With Pacing, With Information, French	C,M,Q,AA	1
	804260-15	With Pacing, With Information, Spanish	D,R	1
	804260-16	With Pacing, With Information, English, International	E,S	1
	804260-17	Without Pacing, With Information, English	F,L,T,Z	1
	804260-28	Without Pacing, With Information, German	G,U	1
	804260-19	Without Pacing, With Information, French	H,N,V,AB	1
	804260-20	Without Pacing, With Information, Spanish	I,W	1
	804260-21	Without Pacing, With Information, English, International	J,X	1
	804260-22	With Pacing, With Information, English, CSA		1
	804260-24	With Pacing, With Information, French, CSA		1
	804260-29	With Pacing, With Information, English	AC	1
	804260-30	With Pacing, With Information, English IEC	AG	1
	804260-31	Without Pacing, With Information, English	AH	1
	804260-32	Without Pacing, With Information, English IEC	AL	1
	804260-33	Without Pacing, With Information, English MIEMSS	AQ	1
	804260-34	Without Pacing, With Information, English Military	AR	1
	804260-35	With Pacing, With Information, English IEC NEMKO	AS	1
	804260-36	With Pacing, With Information, English OUS	AT	1
	804260-37	Without Pacing, With Information, English OUS	AU	1

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5-1 Ref	Part Number	Description (continued from previous page)	Use Code	Qty
	804260-38	With Pacing, With Information, French	AE	1
	804260-39	Without Pacing, With Information, French	AJ	1
	804260-40	With Pacing, With Information, Spanish	AF	1
	804260-41	Without Pacing, With Information, Spanish	AK	1
	804260-42	With Pacing, With Information, English CSA	AM	1
	804260-43	Without Pacing, With Information, English CSA	AN	1
	804260-44	With Pacing, With Information, French CSA	AO	1
	804260-45	Without Pacing, With Information, French CSA	AP	1
	804260-46	With Pacing, With Information, German	AD	1
	804260-47	Without Pacing, With Information, German	AI	1
33	800943-09	**Label,** Symbol, International, High Voltage (Not shown, used on A10)		2
34	801517-04	**Label,** UL (Not shown, used on item 11)	O-AC,AH,AR,AT,AU	1
35	804251-00	**Label,** Warning/Danger, Domestic	A,F,O,T,AC,AH,AQ,AR,AT,AU	1
	804251-01	**Label,** Warning/Danger, CSA	E,J,K-N,S,X,Y-AB,AG,AL,AM-AP,AS	1
	804251-02	**Label,** Warning/Danger, French	C,H,Q,V,AE,AJ	1
	804251-05	**Label,** Warning/Danger, German	B,G,P,U,AD,AI	1
	804251-04	**Label,** Warning/Danger, Spanish	D,I,R,W,AF,AK	1
36	805673-00	**Label,** Warning, Pace, French	AE,AO	1
37	805139-01	**Module,** Pacing Connector	O-S,Y,AA,AC-AG,AM,AO,AS,AT	1
38	805182-01	**Mount,** Yoke, Base		1
39	805181-01	**Mount,** Yoke, Cap		1
40	804236-01	**Mount,** CRT, Front		1
41	804238-01	**Mount,** Relay		1
42	201508-000	**Nut,** Lock, Carbon Steel, KEP, #4-40		21
43	200805-000	**Nut,** Lock, Stainless Steel	AQ	1
44	805079-01	**Nut,** Seal, Auxiliary Connector		1
45	805704-00	**Nut,** Threaded Connector, ECG		1
46	804255-00	**Pad,** Adhesive, Main Bezel		1
47	805071-00	**Pad,** Adhesive, Pacer Bezel		1
48	805087-01	**Plate,** Latch, With studs		3
49	200792-002	**Plug,** Polyethelene, Black	O,S,T,X,AC,AG,AH,AL,AQ-AU	1
50	202186-000	**Plug,** Potentiometer Access, Black, #1138-36024		1

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5-1 Ref	Part Number	Description (continued from previous page)	Use Code	Qty
51	802935-05	**Pushbutton**, Paddle, Charge, Domestic French	A,C,E,F,H,J-N,O,Q,S,T,V,X-AB,AC,AE,AG,AH,AJ,AL-AU	1
	802935-06	**Pushbutton**, Paddle, Charge, German	B,G,P,U,AD,AI	1
	802935-07	**Pushbutton**, Paddle, Charge, Spanish	D,I,R,W,AF,AK	1
52	802935-08	**Pushbutton**, Paddle, Discharge, Domestic	A,F,O,T,AC,AH,AQ,AR,AT,AU	2
	802935-09	**Pushbutton**, Paddle, Discharge, International	B-E,G-N,P-S,U-AB,AD-AG,AI-AP,AS	2
53	802935-14	**Pushbutton**, Paddle, Record, Domestic	A,E,F,J-L,O,S,T,X-Z,AC,AG,AH, AL-AN,AQ-AU	1
	802935-15	**Pushbutton**, Paddle, Record, French	C,H,M,N,Q,V,AA,AB,AE,AJ,AO,AP	1
	802935-16	**Pushbutton**, Paddle, Record, German	B,G,P,U,AD,AI	1
	802935-17	**Pushbutton**, Paddle, Record, Spanish	D,I,R,W,AF,AK	1
54	800516-02	**Resistor**, Defibrillator (R1, Not shown, used on C1, Energy Storage Capacitor)		1
55	804241-05	**Retainer**, Bail, Left		1
56	804241-04	**Retainer**, Bail, Right		1
57	805117-01	**Retainer**, Cable, Control		1
58	200536-009	**Retainer**, Cable Tie, Nylon, 0.10 W x 4.06 L	A-AP,AR-AU	36
	200536-009	**Retainer**, Cable Tie, Nylon, 0.10 W x 4.06 L	AQ	38
59	200536-011	**Retainer**, Cable Tie, Nylon, 0.35 W x 20.90 L		2
60	804239-02	**Retainer**, Coil Cord		1
61	805710-00	**Retainer**, Connector, ECG		1
62	804448-03	**Retainer**, D Connector (Not shown, used on J18)		1
63	804192-01	**Retainer**, Paddle, Front (this part normally welded to Upper Case Enclosure, but may be purchased and replaced separately)		2
64	804256-02	**Retainer**, Paddle, Rear		2
65	202039-001	**Retainer**, Wire, Adhesive Mount, 0.250-0.500		1
66	805186-00	**Retainer**, PFC (Not shown, used on CRT Assembly)		1
67	202253-537	**Screw**, Pan Head, Nylok, 4-40 x 0.31 L	AQ	2
68	202253-536	**Screw**, Pan Head, Nylok, 4-40 x 0.25 L	A-AP,AR,AS	31
	202253-536	**Screw**, Pan Head, Nylok, 4-40 x 0.25 L	AQ, AT, AU	32
69	200476-768	**Screw**, Pan Head, 4-40 x 0.75 L	AQ	1
70	202253-570	**Screw**, Pan Head, Nylok, 6-32 X 0.375 L	A-AP,AR-AU	24
	202253-570	**Screw**, Pan Head, Nylok, 6-32 X 0.375 L	AQ	25
71	200476-536	**Screw**, Pan Head, 4-40 x 0.25 L		1

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5-1 Ref	Part Number	Description (continued from previous page)	Use Code	Qty
72	804244-00	**Seal,** D Connector		1
73	201209-023	**Seal,** O-Ring, Elastometric, ECG		1
74	200060-011	**Seal,** O-Ring, Silicone, 0.551 ID		1
75	805140-01	**Seal,** Pacing Connector Module		1
76	804234-00	**Seal,** Perimeter (Used on Upper Case Enclosure)		1
77	804259-01	**Shield,** High Voltage		1
78	804287-01	**Shield,** Implosion		1
79	805543-00	**Shield,** Capacitor, Cover		1
80	805542-00	**Shield,** Capacitor, End		1
81	804233-02	**Shield,** Pacer, Lower	O-AU	1
82	804232-02	**Shield,** Pacer, Upper	O-S,Y,AA,AC-AG,AM,AO,AS,AT	1
83	805147-00	**Shield,** Paddle Retainer		1
84	805899-00	**Shield,** PFC, Anode Supply (Not shown, used on A3, Anode Power Supply)	AR	1
85	804243-05	**Shield,** Preamp, Lower, Painted (Not shown)		1
86	804447-06	**Spacer,** Foam, 0.65 D x 0.25 T		A/R
87	805338-00	**Spring,** Flat, Steel, #8, 1.5 L, 0.020 T		1
88	804205-00	**Standoff,** Spacer, M/F, Molded, 0.798 L		5
89	804205-01	**Standoff,** Spacer, M/F, Molded, 2.850 L		1
90	804209-01	**Switch,** Battery Select (POWER)		1
91	201765-002	**Tape,** Adhesive, Foam, 1.000 W x 0.125 T (Not shown)		A/R
92	201765-008	**Tape,** Adhesive, Foam, 1.0 W x 0.25 T (Not shown)		A/R
93	201765-016	**Tape,** Adhesive, Foam, 0.750 W x 0.062 T (Not shown)		A/R
94	201765-017	**Tape,** Adhesive, Foam, 1.000 W x 0.062 T (Not shown)		A/R
95	201765-096	**Tape,** Adhesive, Foam, 1.380 W x 0.125 T		A/R
96	201765-100	**Tape,** Adhesive, Foam, 1.0 W x 0.03 T (Not shown)		A/R
97	202446-000	**Tape,** Double-sided		A/R
98	200804-015	**Washer,** Flat, #4 x 0.317 OD/0.016 T	A-E,K,M,O-S,Y,AA,AC-AG,AM,AO,AS, AT	14
	200804-015	**Washer,** Flat, #4 x 0.317 OD/0.016 T	F-J,L,N,T-X,Z,AB,AH-AL,AN,AP,AQ,AU	12
	200804-015	**Washer,** Flat, #4 x 0.317 OD/0.016 T	AR	13
99	200804-016	**Washer,** Flat, #4 x 0.312 OD/0.03 T (Used with A10)		4
100	200144-042	**Washer,** Nylon, #4 (Not shown, used with item 67)	AQ	2
101	200431-849	**Washer,** Shoulder, Insulator, #4 x 0.115 ID/0.200 OD		1

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5-3 Ref	Part Number	Description	Use Code	Qty
A7	804189-00	**Recorder Assembly, GSI**		REF
2	GSI624-10256	**Base**, chassis		1
3	GSI624-11759	**Bracket Mod**, printhead (pre-assembled at GSI)*		1
4	GSI624-10278	**Bracket**, pivot head		1
5	GSI624-10253	**Bumper**, printhead		2
6	GS1624-10270	**Cover**, gear		1
7	GSI624-10254	**Door**, chassis		1
8	GSI624-10260	**Ejector Assembly**, paper		1
9	GSI625-10268	**Gear**, idler 108T		1
10	GSI625-10266	**Gear**, motor 15T		1
11	GSI625-10267	**Gear**, motor 31T		1
12	GSI624-10224	**Keyshim Gear**		1
13	GSI624-10225	**Label**, paper feed		1
14	GSI624-10255	**Latch**, chassis		1
15	GSI624-10257	**Link**, latch plate		1
16	GSI624-10258	**Link**, printhead		1
17	GSI610-102341	**Motor Assembly/Gear**		1
18	GSI420-06175	**Nameplate**, label		1
19	GSI52-41003	**O-Ring**, IB Moore #2-104		1
20	GSI75-00007	**Printhead**, KST 488MPDI (pre-assembled at GSI)*		1
21	GSI615-200051	**Printroller Assembly**		1
22	GSI5E-513	**Ring**, rtng TRU 5100-18		1
23	GSI5E-519	**Ring**, rtng TRU 5133-9		4
24	GSI41-22001	**Screw**, flat head, 90 M2, OX, 4 x 6mm		3
25	GSI42-50083	**Screw**, pan head, 4-40 x 0.25		2
26	GSI41-50082	**Screw**, pan head		1
27	GSI624-10246	**Shaft**		2
28	GSI625-10263	**Shaft Roller**		1
29	GSI624-10262	**Shaft**, linkage		2
30	GSI620-10244	**Spring**		2
31	GSI615-102331	**Spring Assembly**		1
32	GSI624-11893	**Tubing** (not shown, used on item 17)		A/R
		*Specialized alignment equipment required. Replacement of entire Strip Chart Recorder is recommended.		

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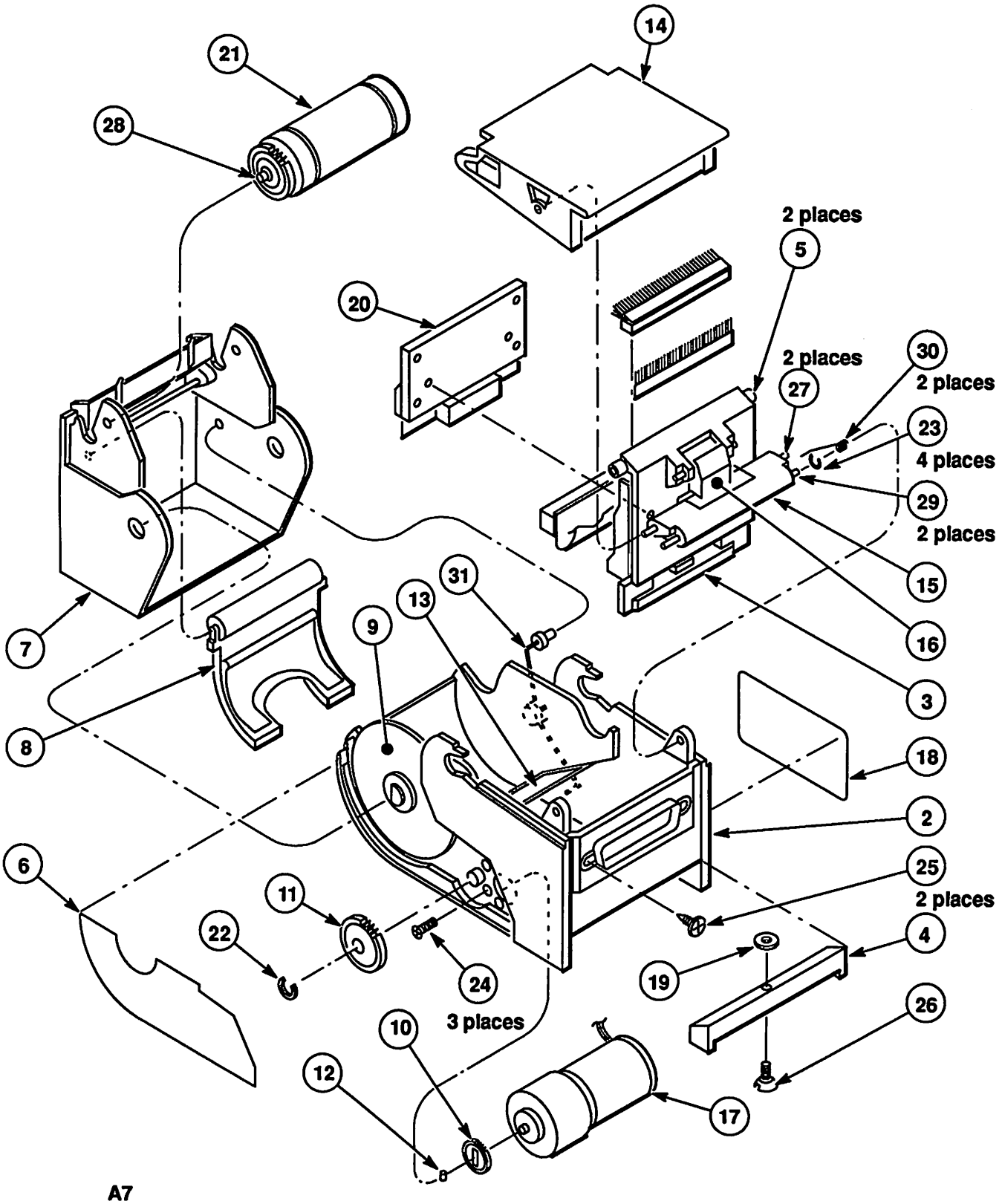

Figure 5–3 Recorder Assembly
Part Number 804189-00
(Sheet 1 of 2)

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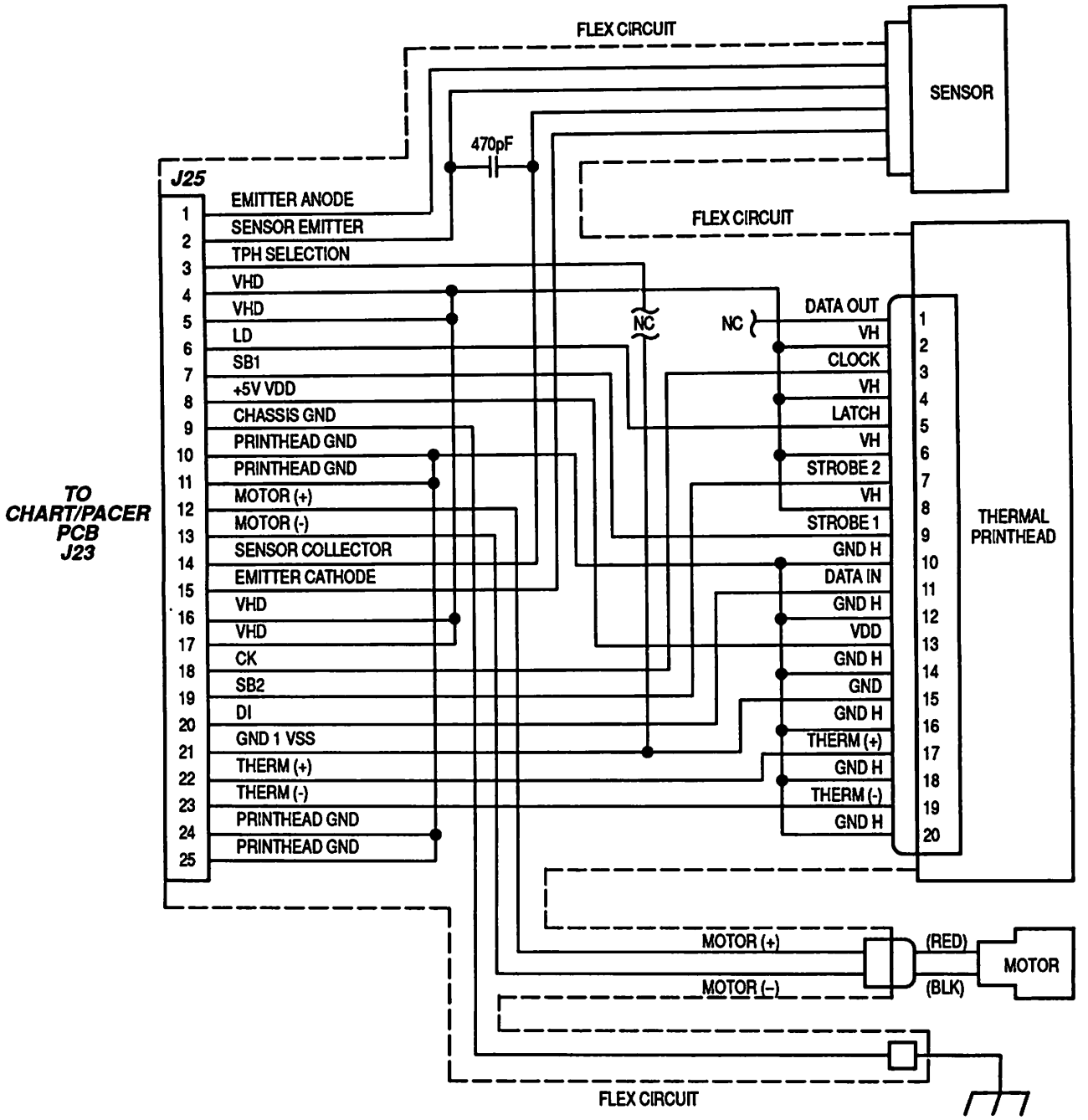

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Figure 5–3 Recorder Assembly
Part Number 804189-00
(Sheet 2 of 2)

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5-4 Ref	Part Number	Description	Use Code	Qty
A8	804250-02	**Paddle Assembly**, Apex	A	REF
	804250-04	**Paddle Assembly**, Apex, NEMKO	C	REF
	804250-01	**Paddle Assembly**, Sternum	B	REF
	804250-03	**Paddle Assembly**, Sternum, NEMKO	D	REF
	804250-06	**Paddle Assembly**, Apex	E	REF
	804250-08	**Paddle Assembly**, Apex, NEMKO	G	REF
	804250-05	**Paddle Assembly**, Sternum	F	REF
	804250-07	**Paddle Assembly**, Sternum, NEMKO	H	REF
A6	804258-02	**Energy Select PCB Assembly** (See Figure 5–13, page 5–70)	B,D,F,H	1
2	202221-007	**Adhesive**, Hot Melt, Thermoplastic (Not shown)		A/R
3	802930-05	**Base**, Sternum Paddle	B,D,F,H	1
4	802930-06	**Base**, Apex Paddle	A,C,E,G	1
5	804214-04	**Coil Cord Assembly**, Apex	A,E	1
	804214-06	**Coil Cord Assembly**, Apex, NEMKO	C,G	1
6	804214-05	**Coil Cord Assembly**, Sternum	B,F	1
	804214-07	**Coil Cord Assembly**, Sternum, NEMKO	D,H	1
7	804246-02	**Cover**, Apex Paddle	A,C,E,G	1
8	804246-03	**Cover**, Sternum Paddle	B,D,F,H	1
9	802902-02	**Electrode Plate Assembly**, Apex Paddle	A,C,E,G	1
10	802902-03	**Electrode Plate Assembly**, Sternum Paddle	B,D,F,H	1
11	802944-01	**Gasket**, Paddle		1
12	802931-00	**Handle**, Paddle, Apex	A,C,E,G	1
13	802931-01	**Handle**, Paddle, Sternum	B,D,F,H	1
14	802932-00	**Key**, Retainer, Coil Cord		1
15	804248-00	**Knob**, Energy Select	B,D,F,H	1
16	800819-02	**Label**, Serial Number, Paddle, Sternum	B,F	1
	800819-03	**Label**, Serial Number, Paddle, Apex	A,E	1
	800819-04	**Label**, Serial Number, Paddle, Sternum, NEMKO	D,H	1
	800819-05	**Label**, Serial Number, Paddle, Apex, NEMKO	C,G	1
17	200491-048	**LED**, Yellow	A,C,E,G	1
18	201508-004	**Nut**, Kep, 8-32 x 0.312 T		3
19	200536-009	**Retainer**, Cable Tie, Nylon, 0.10 W x 4.06 L (Not shown)		1
20	202187-001	**Retainer**, Knob, Green	B,D,F,H	1
21	200476-536	**Screw**, Pan Head, 4-40 x 0.250 L		7
22	805241-00	**Seal**, LED, Apex Paddle	A,C,E,G	1
23	804231-00	**Shield**, High Voltage		1
24	804697-03	**Switch**, Pushbutton, SPST	A,C,E,G	3
	804697-03	**Switch**, Pushbutton, SPST	B,D,F,H	1

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5–5 Ref	Part Number	Description	Use Code	Qty
A9	805230-01	Status Display Module ⚠		REF

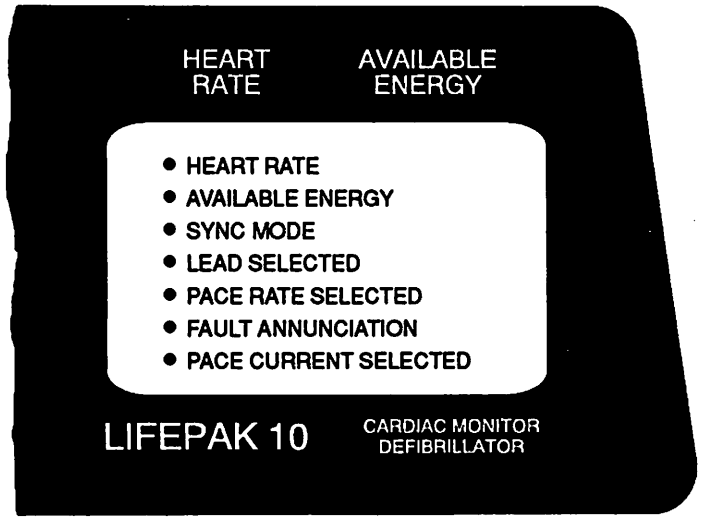

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Figure 5–5 Status Display Module Part Number 805230 (Sheet 1 of 1)

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5–6 Ref	Part Number	Description	Use Code	Qty
A10	800240-12	Relay Assembly, Transfer (Not repairable)		REF

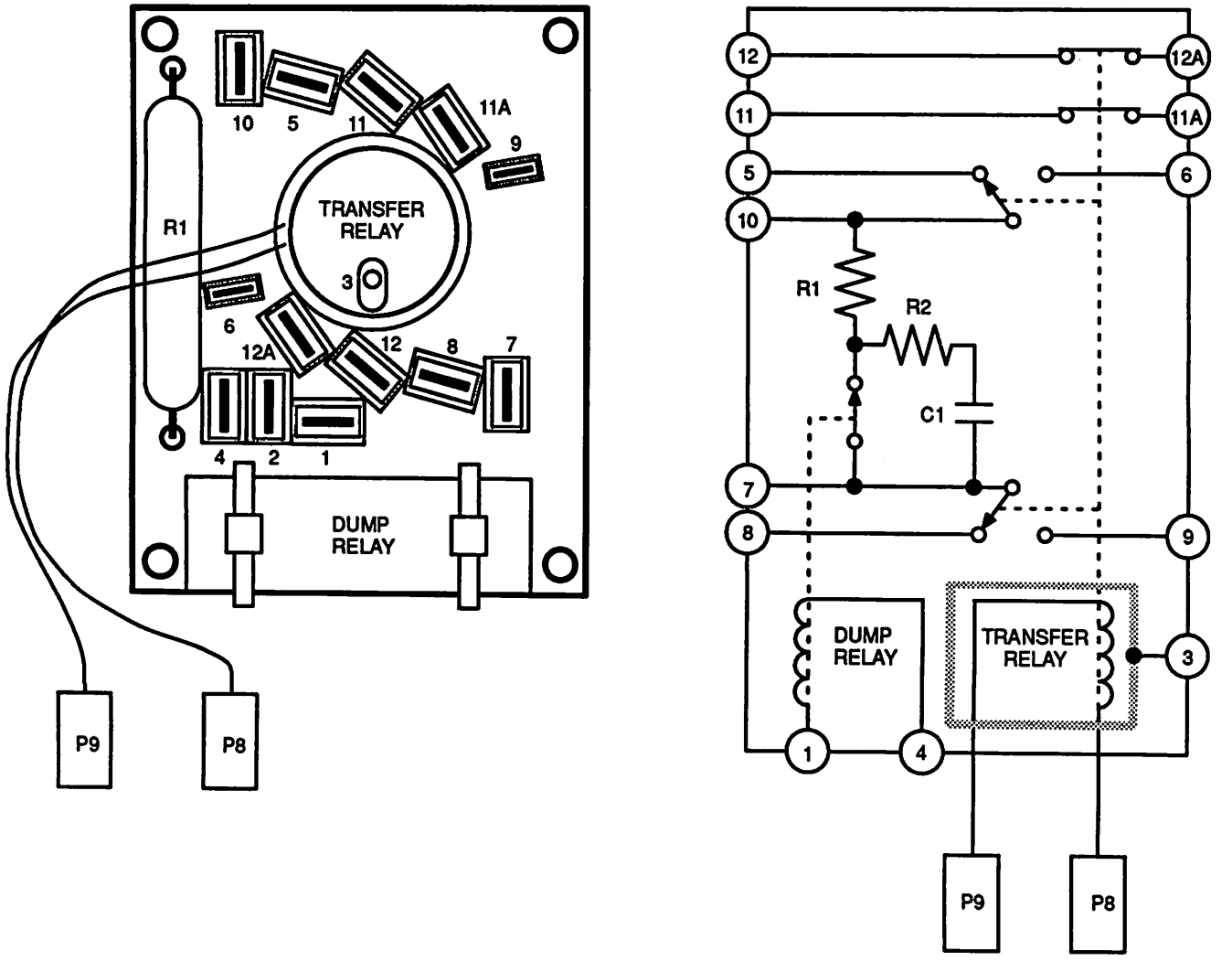

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Figure 5–6 Relay Assembly
Part Number 800240
(Sheet 1 of 1)

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5-7 Ref	Part Number	Description	Use Code	Qty
A1	804204-01	System PCB Assembly ⚠2	A	REF
	804204-02	System PCB Assembly ⚠2	B	REF
	804204-04	System PCB Assembly ⚠2	C	REF
	804204-05	System PCB Assembly ⚠2	D	REF
	804204-08	System PCB Assembly, MIEMSS ⚠2	E	REF
	804204-09	System PCB Assembly ⚠2	F	REF
	804204-10	System PCB Assembly, MIEMSS ⚠2	G	REF
	804204-11	System PCB Assembly ⚠2	H	REF
	804204-12	System PCB Assembly, MIEMSS ⚠2	I	REF
	804204-13	System PCB Assembly ⚠2	J	REF
	804204-14	System PCB Assembly, MIEMSS ⚠2	K	REF
	804204-15	System PCB Assembly ⚠2	L	REF
AS1	804296-03	Anode Power Supply CRT, 12kV (A3, Figure 5–10, page 5–66)	A	1
	804296-05	Anode Power Supply CRT, 12kV (A3, Figure 5–10, page 5–66)	B-L	1
C1	201628-012	Capacitor, 0.1µF/50V, 5%	A-F	11
	201628-012	Capacitor, 0.1µF/50V, 5%	G-L	10
C2	201628-018	Capacitor, 1.0µF/50V, 5%	A	8
	201628-018	Capacitor, 1.0µF/50V, 5%	B-L	7
C3,4	202102-030	Capacitor, Electrolytic, 3300µF/25V, 20%		2
C5-7	201628-000	Capacitor, 0.001µF/50V, 5%		3
C8,9	202102-024	Capacitor, Electrolytic, 330µF/25V, 20%		4
C10	201628-014	Capacitor, 0.22µF/50V, 5%	A	7
	201628-014	Capacitor, 0.22µF/50V, 5%	B-L	8
C11	200893-034	Capacitor, 0.1µF/50V, 10%	A	26
	200893-034	Capacitor, 0.1µF/50V, 10%	B-L	27
C12	200049-039	Capacitor, 0.1µF/50V, 20%		1
C13	200893-046	Capacitor, 1.0µF/50V, 10%	A	6
	200893-046	Capacitor, 1.0µF/50V, 10%	B-J	7
	200893-046	Capacitor, 1.0µF/50V, 10%	K,L	8
C14		(Same as C2)		

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5-7 Ref	Part Number	Description (continued from previous page)	Use Code	Qty
C15,16	202068-027	Capacitor, 20µF/50V, 20%		2
C17		(Same as C8)		
C18	202102-008	Capacitor, Electrolytic, 680µF/10V,20%		1
C19		(Same as C8)		
C20,21	202102-001	Capacitor, Electrolytic, 1000µF/6.3V, 20%		2
C22		(Same as C1)		
C23		(Same as C2)		
C24,25		(Same as C13)		
C26	201628-010	Capacitor, 0.047µF/50V, 5%		1
C27		(Same as C11)		
C28-32		(Same as C10)		
C33		(Same as C11)		
C34		(Same as C1)		
C35		(Same as C11)		
C36	200901-046	Capacitor, 0.01µF/50V, 5%		3
C37	200901-022	Capacitor, 100pF/50V, 5%		5
C38	200901-095	Capacitor, 1000pF/100V, 5%		5
C39-41		(Same as C11)		
C42		(Same as C37)		
C43		(Same as C2)	A	
		(Same as C10)	B-L	
C44	200901-134	Capacitor, 22pF/50V, 10%		3
C45		(Same as C11)		
C46		(Same as C36)		
C47		(Same as C13)		
C48	201628-017	Capacitor, 0.68µF/50V, 5%		1
C49	200893-030	Capacitor, 0.047µF/50V, 10%		2
C50	200901-225	Capacitor, 6800pF/100V, 10%		1
C51	200901-026	Capacitor, 220pF/50V, 5%		1
C52,53		(Same as C11)		
C54	200593-015	Capacitor, 1000pF/1kV, 10%		1
C55,56		(Same as C11)		
C57		(Same as C44)		

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5-7 Ref	Part Number	Description (continued from previous page)	Use Code	Qty
C58		(Same as C11)		
C59,60	200205-024	**Capacitor**, Electrolytic, 10µF/25V, +50%	A	9
	200205-024	**Capacitor**, Electrolytic, 10µF/25V, +50%	B-L	8
C61		(Same as C11)		
C62		(Same as C38)		
C63	200893-022	**Capacitor**, 0.01µF/50V, 10%		7
C64		(Same as C38)		
C65	200893-026	**Capacitor**, 0.022µF/50V, 10%		3
C66		(Same as C38)		
C67		(Same as C36)		
C68,69		(Same as C11)		
C70		(Same as C1)		
C71	200893-028	**Capacitor**, 0.033µF/50V, 10%	G-L	2
		(Same as C1)	A-F	
C72		(Same as C59)		
C73,74		(Same as C11)		
C75		(Same as C1)		
C76		(Same as C63)		
C77		(Same as C65)		
C78		(Same as C63)		
C79	201628-006	**Capacitor**, 0.01µF/50V, 5%		3
C80		(Same as C11)		
C81		(Same as C44)		
C82		(Same as C37)		
C83		(Same as C11)		
C84		(Same as C59)		
C85		(Same as C13)		
C86	200893-050	**Capacitor**, 2.2µF/50V, 10%		1
C87		(Same as C13)		
C88		(Same as C59)	A	
	202102-032	**Capacitor**, Electrolytic, 100µF/35V, 20%	B-L	1
C89	200901-042	**Capacitor**, 4700pF/50V, 5%		1
C90		(Same as C59)		

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5-7 Ref	Part Number	Description (continued from previous page)	Use Code	Qty
C91,92	202102-020	Capacitor, Electrolytic, 2200µF/16V, 20%		2
C93	202210-000	Capacitor, 4700pF/9kV, 20%		1
C94		(Same as C2)		
C95,96		(Same as C11)		
C97		(Same as C37)		
C98		(Same as C11)		
C99		(Same as C2)		
C100		(Same as C11)		
C101	200205-021	Capacitor, Electrolytic, 470µF/16V, 50%		1
C102	200701-030	Capacitor, Electrolytic, 4.7µF/50V, 20%		1
C103		(Same as C63)		
C104		(Same as C79)		
C105-107		(Same as C59)		
C108	200205-032	Capacitor, Electrolytic, 1000µF/25V, 50%	A	1
	200205-190	Capacitor, Electrolytic, 1000µF/50V, 50%	B-L	1
C109, 110	200893-006	Capacitor, 470pF/50V, 10%		5
C111, 112		(Same as C11)		
C113		(Same as C10)		
C114, 115		(Same as C109)		
C116		(Same as C37)		
C117		(Same as C1)		
C118		(Same as C109)		
C119		(Same as C38)		
C120		(Same as C63)		
C121-124		(Same as C1)		
C125		(Same as C79)		
C126, 127		(Same as C63)		
C128, 129		(Same as C2)		
C130	200893-028	Capacitor, 0.033µF/50V, 10%	A-F	1
		(Same as C71)	G-L	
C131	201628-014	Capacitor, 0.22µF/50V, 5%		1
C132		(Same as C65)		
C133		(Same as C49)		

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5-7 Ref	Part Number	Description (continued from previous page)	Use Code	Qty
C134	200744-023	**Capacitor**, 3µF/50V, 5%		1
C135	200744-120	**Capacitor**, 2200pF/400V, 5%		1
C136		(Same as C11)	B-L	1
C137		(Same as C13)	B-L	1
C138		(Same as C13)	K,L	1
CR1,2	200971-000	**Diode**, 1N914B, 8ns, PIV 75	A	27
	200971-000	**Diode**, 1N914B, 8ns, PIV 75	B-L	33
CR3	200284-005	**Diode**, 1N4005, 1A, PIV 600		4
CR4	200658-002	**Diode**, MR812, 200ns, PIV 200	A-C	1
	202136-003	**Diode**, UF4004	D-L	1
CR5-8	201528-005	**Diode**, MUR810, 8A, PIV 100		4
CR9	201749-012	**Diode**, Bipolar, SA176, 17V		1
CR10-16		(Same as CR1)		
CR17	200086-008	**Diode**, Zener, 1N4622, 65mA/3.9V		1
CR18-20		(Same as CR1)		
CR21,22		(Same as CR3)		
CR23	201128-000	**Diode**, Fast Recovery, 3XF1, 300ns, PIV 100		1
CR24	200635-053	**Diode**, 1.5KE82A 82V		1
CR28-30		(Same as CR1)		
CR31	200881-001	**Diode**, SFES12K, 250ns, PIV 12k	A-D	1
	200881-004	**Diode**, Fast Recovery, 250ns, PIV 12k	E-L	
CR32		(Same as CR3)		
CR33-41		(Same as CR1)		
CR42	200086-037	**Diode**, Zener, 1N4122, 6.6mA/36V		1
CR43-45		(Same as CR1)		
CR46	202017-000	**Diode**, Bridge, VM48, 1A/400V	A	1
CR46-49		(Same as CR1)	B-L	1
CR50,51		(Same as CR1)	B-L	1
CR52	200083-000	**Diode**, Schottky, 1N5817	I-L	1
F1	200256-108	**Fuse**, Slow Blow, 15A		1

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5-7 Ref	Part Number	Description (continued from previous page)	Use Code	Qty
J1	201191-233	Connector, Ribbon Cable, 40 Position/Right Angle/4 Wall		1
J2A	202128-026	Connector, Header, Straight, 4 Contact, 0.100	A-F	3
	202128-026	Connector, Header, Straight, 4 Contact, 0.100	G-L	4
J2B	202128-024	Connector, Header, Straight, 2 Contact, 0.100	A,G-L	4
	202128-024	Connector, Header, Straight, 2 Contact, 0.100	B-F	5
J2C		(Same as J2B)	B-L	
J3		(Same as J2B)	A-F	
		(Same as J2A)	G-L	
J4,5	201504-003	Terminal, Quick Connect, Male, 0.187 W/0.020 T, PCB Mount		7
J6		(Same as J2B)		
J7-9		(Same as J4)		
J10		(Same as J2A)		
J11		(Same as J2B)		
J14		(Same as J2A)		
J15	202128-029	Connector, Header, Straight, 7 Contact, 0.100		1
J16,17	202128-027	Connector, Header, Straight, 5 Contact, 0.100		2
J20	805706-00	Flex Assembly, ECG		1
J53,54		(Same as J4)		
K1	202045-001	Relay, MR604-24-SR		1
L1,2	200808-026	Inductor, Ferrite	A	2
	200808-029	Inductor, Ferrite	B-L	2
L3	201409-036	Inductor, 100mH	A	1
Q1	202076-000	Transistor, N-Channel, Hex, FET, IRFD120, 4 Contact ▲2		1
Q2	202155-000	Transistor, P-Channel, Hex, DIP, IRFD9010, 1W, 4 Contact ▲2		2
Q3	202168-000	Transistor, N-Channel, Power FET, IRFZ34, TO-220 ▲2		3
Q4	200888-001	Transistor, PNP, PN2907A, TO-92	A	3
	200888-001	Transistor, PNP, PN2907A, TO-92	B-L	4
Q5	200942-001	Transistor, NPN, PN2222A, TO-92		5
Q6-8	200585-001	Transistor, FET, VN0106N3, TO-92 ▲2		10
Q9		(Same as Q5)		

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5-7 Ref	Part Number	Description (continued from previous page)	Use Code	Qty
Q10,11		(Same as Q6)		
Q12	201738-001	**Transistor**, Power FET, VP0106N3, TO-92 ⚠	A	2
	201738-001	**Transistor**, Power FET, VP0106N3, TO-92 ⚠	B-L	1
Q13		(Same as Q6)		
Q14		(Same as Q5)		
Q15		(Same as Q4)		
Q16		(Same as Q5)		
Q17		(Same as Q6)		
Q18		(Same as Q4)		
Q19		(Same as Q5)		
Q20		(Same as Q6)		
Q21		(Same as Q12)	A	
		(Same as Q4)	B-L	
Q22		(Same as Q2)		
Q23,24		(Same as Q6)		
Q25A, 25B	201696-000	**Transistor**, NPN, Power MOSFET, IRF540, TO-220AB ⚠		2
Q26,27		(Same as Q3)		
R1	200054-193	**Resistor**, 1 kΩ, 1/8W, 1%, RN55C	A	14
	200054-193	**Resistor**, 1 kΩ, 1/8W, 1%, RN55C	B-C	13
	200054-259	**Resistor**, 4.99 kΩ, 1/8W, 1%, RN55C	D-L	6
R2,3	200054-288	**Resistor**, 10 kΩ, 1/8W, 1%, RN55C	A	26
	200054-288	**Resistor**, 10 kΩ, 1/8W, 1%, RN55C	B-F	30
	200054-288	**Resistor**, 10 kΩ, 1/8W, 1%, RN55C	G-L	29
R4	200054-353	**Resistor**, 47.5 kΩ, 1/8W, 1%, RN55C		1
R5	200054-313	**Resistor**, 18.2 kΩ, 1/8W, 1%, RN55C	A	1
	200054-311	**Resistor**, 17.4 kΩ, 1/8W, 1%, RN55C	B-D	1
	200054-309	**Resistor**, 16.5 kΩ, 1/8W, 1%, RN55C	E-L	1
R6	200054-165	**Resistor**, 511 Ω, 1/8W, 1%, RN55C		2
R7		(Same as R2)		
R8	200470-016	**Resistor**, 4.7Ω, 1/4W, 5%		1
R9	200054-222	**Resistor**, 2 kΩ, 1/8W, 1%, RN55C		6

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5-7 Ref	Part Number	Description (continued from previous page)	Use Code	Qty
R10,11	200270-000	Resistor, 0.10Ω, 2W, 5%		2
R12		(Same as R9)		
R13	200054-252	Resistor, 4.22 kΩ, 1/8W, 1%, RN55C		1
R14	200054-317	Resistor, 20 kΩ, 1/8W, 1%, RN55C		6
R15	200054-097	Resistor, 100Ω , 1/8W, 1%, RN55C		5
R16	201527-000	Wire, Jumper, Molded, 1/4W, 5%	A	1
R17		(Same as R15)		
R18	200054-069	Resistor, 51.1Ω, 1/8W, 1%		6
R19	200054-417	Resistor, 221 kΩ, 1/8W, 1%, RN55C		2
R20	200054-321	Resistor, 22.1 kΩ, 1/8W, 1%, RN55C		2
R21		(Same as R18)		
R22		(Same as R6)		
R23		(Same as R2)		
R24	200054-066	Resistor, 47.5 kΩ, 1/8W, 1%, RN55C		2
R25		(Same as R2)		
R26		(Same as R1)	A-C	
	200054-193	Resistor, 1 kΩ, 1/8W, 1%, RN55C	D-L	12
R27	200054-384	Resistor, 100 kΩ, 1/8W, 1%, RN55C	A	21
	200054-384	Resistor, 100 kΩ, 1/8W, 1%, RN55C	B-L	20
R28		(Same as R15)		
R29-31	200054-126	Resistor, 200Ω, 1/8W, 1%, RN55C		3
R32	200054-355	Resistor, 49.9 kΩ, 1/8W, 1%, RN55C		12
R33	200054-307	Resistor, 15.8 kΩ, 1/8W, 1%, RN55C		2
R34		(Same as R1)	A-C	
		(Same as R26)	D-L	
R35	200054-372	Resistor, 75 kΩ, 1/8W, 1%, RN55C		3
R36-38	200054-231	Resistor, 2.49 kΩ, 1/8W, 1%, RN55C		3
R39	200054-480	Resistor, 1 MΩ, 1/8W, 1%, RN55C	A	2
	200054-480	Resistor, 1 MΩ, 1/8W, 1%, RN55C	B-L	3
R40	200054-376	Resistor, 82.5 kΩ, 1/8W, 1%, RN55C		1
R41	200054-259	Resistor, 4.99 kΩ, 1/8W, 1%, RN55C	A	4
	200054-259	Resistor, 4.99 kΩ, 1/8W, 1%, RN55C	B-C	5
		(Same as R1)	D-L	

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5-7 Ref	Part Number	Description (continued from previous page)	Use Code	Qty
R42,43		(Same as R27)		
R44	200054-508	Resistor, 2 MΩ, 1/8W, 1%, RN55C		4
R45		(Same as R35)		
R46		(Same as R27)		
R47		(Same as R2)		
R48		(Same as R20)		
R49	200054-139	Resistor, 274Ω , 1/8W, 1%, RN55C		1
R50		(Same as R32)		
R51	200054-272	Resistor, 6.81 kΩ, 1/8W, 1%, RN55C		1
R52		(Same as R2)		
R53		(Same as R14)		
R54		(Same as R2)		
R55	200216-026	Resistor, 3.01Ω, 1W, 1%		1
R56	200054-305	Resistor, 15 kΩ, 1/8W, 1%, RN55C		1
R57		(Same as R1)	A-C	
		(Same as R26)	D-L	
R58		(Same as R27)		
R59,60	201527-000	Wire, Jumper, Molded, 1/4W, 5%		4
R61	200054-334	Resistor, 30.1 kΩ, 1/8W, 1%, RN55C	A-F	1
	200054-334	Resistor, 30.1 kΩ, 1/8W, 1%, RN55C	G-L	2
R62,63		(Same as R27)		
R64		(Same as R14)		
R65		(Same as R35)		
R66	200054-452	Resistor, 511 kΩ, 1/8W, 1%, RN55C		2
R67		(Same as R19)		
R68	200054-284	Resistor, 9.09 kΩ, 1/8W, 1%, RN55C		1
R69		(Same as R2)		
R70-72		(Same as R1)	A-C	
		(Same as R26)	D-L	
R73		(Same as R2)		
R74		(Same as R1)	A-C	
		(Same as R26)	D-L	
R75	200054-299	Resistor, 13 kΩ, 1/8W, 1%, RN55C		2

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5-7 Ref	Part Number	Description (continued from previous page)	Use Code	Qty
R76,77		(Same as R2)		
R78		(Same as R1)	A-C	
		(Same as R26)	D-L	
R79	200054-300	Resistor, 13.3 kΩ, 1/8W, 1%, RN55C		1
R80	200054-282	Resistor, 8.66 kΩ, 1/8W, 1%, RN55C		1
R81		(Same as R1)	A-C	
		(Same as R26)	D-L	
R82		(Same as R27)		
R83,84		(Same as R41)	A-C	
		(Same as R1)	D-L	
R85	200054-338	Resistor, 33.2 kΩ, 1/8W, 1%, RN55C		3
R86		(Same as R18)		
R87		(Same as R27)		
R88		(Same as R75)		
R89		(Same as R27)		
R90		(Same as R32)		
R91		(Same as R18)		
R92	200054-155	Resistor, 402Ω, 1/8W, 1%, RN55C		1
R93		(Same as R9)		
R94	200054-267	Resistor, 6.04kΩ, 1/8W, 1%, RN55C		1
R95		(Same as R27)		
R96	200054-250	Resistor, 4.02kΩ, 1/8W, 1%, RN55C		1
R97	200054-226	Resistor, 2.21kΩ, 1/8W, 1%, RN55C		1
R98		(Same as R2)		
R99	200054-394	Resistor, 127kΩ, 1/8W, 1%, RN55C		1
R100	200054-427	Resistor, 280kΩ, 1/8W, 1%, RN55C		2
R101, 102		(Same as R15)		
R103		(Same as R2)	A-F	
		(Same as R61)	G-L	
R104		(Same as R2)		
R105		(Same as R9)		
R106, 107		(Same as R2)		
R108		(Same as R100)		

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5-7 Ref	Part Number	Description (continued from previous page)	Use Code	Qty
R109		(Same as R2)		
R110		(Same as R32)		
R111	200054-349	**Resistor**, 43.2kΩ, 1/8W, 1%, RN55C		1
R112		(Same as R2)		
R113		(Same as R32)		
R114	202071-001	**Resistor**, 50MΩ, 1W, 5%, MG730		2
R115		(Same as R1)	A-C	
		(Same as R26)	D-L	
R116		(Same as R27)		
R117, 118	200054-154	**Resistor**, 392Ω, 1/8W, 1%, RN55C		3
R119-121		(Same as R27)		
R122	200054-276	**Resistor**, 7.50kΩ, 1/8W, 1%, RN55C		1
R123		(Same as R14)		
R124	200054-260	**Resistor**, 5.11kΩ, 1/8W, 1%, RN55C		4
R125, 126	200054-001	**Resistor**, 10Ω, 1/8W, 1%, RN55C		2
R127		(Same as R2)		
R128		(Same as R124)		
R129		(Same as R2)		
R130		(Same as R18)		
R131		(Same as R124)		
R132		(Same as R18)		
R133	200121-005	**Resistor**, 1Ω, 3W, 1%		1
R134	200470-000	**Resistor**, 1Ω, 1/4W, 5%		2
R135		(Same as R1)	A-C	
		(Same as R26)	D-L	
R136, 137		(Same as R59)		
R138		(Same as R32)		
R139		(Same as R39)		
R140		(Same as R32)		
R141		(Same as R1)	A-C	
		(Same as R26)	D-L	
R142		(Same as R124)		
R143-145		(Same as R2)		

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5-7 Ref	Part Number	Description (continued from previous page)	Use Code	Qty
R146	201155-003	Resistor, 1000MΩ, 7.5kV		1
R147	200839-169	Resistor, 562Ω, 1/4W, 1%		1
R148		(Same as R1)	A,D-L	
		(Same as R41)	B-C	
R149		(Same as R27)	A	
		(Same as R2)	B-L	
R150, 151	200054-413	Resistor, 200Ω, 1/8W, 1%, RN55C		3
R152, 153	801967-01	Resistor, Matched Pair, 500kΩ, 7.5V		1
R154		(Same as R66)		
R155	200270-066	Resistor, 56Ω, 2W, 5%		1
R156		(Same as R2)		
R157		(Same as R33)		
R158		(Same as R134)		
R159		(Same as R85)		
R160	200054-360	Resistor, 56.2kΩ, 1/8W, 1%, RN55C		2
R161	200470-012	Resistor, 3.3kΩ, 1/4W, 5%		1
R162		(Same as R85)		
R163	200054-401	Resistor, 150kΩ, 1/8W, 1%, RN55C		1
R164, 165	202149-030	Potentiometer, 100kΩ, 20%		4
R166		(Same as R27)		
R167	200054-316	Resistor, 19.6kΩ, 1/8W, 1%, RN55C		2
R168	200839-130	Resistor, 221Ω, 1/4W, 1%		3
R169, 170	200054-206	Resistor, 1.37kΩ, 1/8W, 1%, RN55C		2
R171		(Same as R9)		
R172		(Same as R160)		
R173	200054-329	Resistor, 26.7kΩ, 1/8W, 1%, RN55C		1
R174		(Same as R24)		
R175, 176		(Same as R14)		
R177, 178		(Same as R27)		
R179, 180		(Same as R32)		
R181	200054-247	Resistor, 3.74kΩ, 1/8W, 1%, RN55C		2
R182	200054-575	Resistor, 10MΩ, 1/8W, 1%, RN55C		2
R183, 184	202149-026	Potentiometer, 10kΩ, 0.5W, 20%		3

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5-7 Ref	Part Number	Description (continued from previous page)	Use Code	Qty
R185		(Same as R41)	A-C	
		(Same as R1)	D-L	
R186		(Same as R150)		
R187		(Same as R164)		
R188		(Same as R167)		
R189, 190		(Same as R168)		
R191		(Same as R27)		
R192	200054-268	**Resistor**, 6.19kΩ, 1/8W, 1%, RN55C		2
R193	200054-239	**Resistor**, 3.01kΩ, 1/8W, 1%, RN55C		2
R194		(Same as R2)		
R195		(Same as R9)		
R196-198		(Same as R44)		
R199-201		(Same as R32)		
R202		(Same as R181)		
R203		(Same as R182)		
R204		(Same as R27)		
R205		(Same as R192)		
R206		(Same as R193)		
R207		(Same as R114)		
R208		(Same as R117)		
R212		(Same as R183)		
R215	200055-608	**Resistor**, 22MΩ, 1/8W, 1%, RN55C	B-D	2
	200055-609	**Resistor**, 22.1MΩ, 1/8W, 1%, RN55C	E-L	2
R216		(Same as R215)		
R217		(Same as R2)	B-L	
R218		(Same as R39)	B-L	
R219		(Same as R164)		
R220	202149-027	**Potentiometer**, 20kΩ, 0.5W, 20%	B-L	1
R221, 222		(Same as R2)	B-L	
RN1	200424-039	**Resistor Network**, 15 x 10kΩ, 0.10W, 2%, 16 Contact		1
RN2	200043-065	**Resistor Network**, 8 x 10kΩ, 1.5W, 2%, 16 Contact		3
RN3	200043-019	**Resistor Network**, 8 x 130Ω, 1.5W, 2%, 16 Contact		1

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5-7 Ref	Part Number	Description (continued from previous page)	Use Code	Qty
RN4	200043-077	Resistor Network, 8 x 100kΩ, 1.5W, 2%, 16 Contact	A	3
	200043-077	Resistor Network, 8 x 100kΩ, 1.5W, 2%, 16 Contact	B-L	2
RN5		(Same as RN2)		
RN6	200043-081	Resistor Network, 8 x 220kΩ, 1.5W, 2%, 16 Contact		1
RN7		(Same as RN4)	A	
	200423-074	Resistor Network, 8 x 50kΩ, 1.75W, 2%, 16 Contact	B-L	1
RN8, 9	200424-051	Resistor Network, 15 x 100kΩ, 0.10W, 2%, 16 Contact		4
RN10		(Same as RN4)		
RN11, 12		(Same as RN8)		
RN13		(Same as RN2)		
RN14	804247-00	Resistor Network, Precision SIP, 0.15%		1
T1	804294-01	Transformer, Power Supply		1
T2	804450-00	Transformer, Isolation	A-D	1
	804450-02	Transformer, Isolation	E-L	1
T3	804295-00	Transformer, High Voltage Capacitor Charger	A	1
	804295-01	Transformer, High Voltage Capacitor Charger	B-L	1
U1	202050-000	IC, Linear, PWM3843N		1
U2	202167-000	IC, Interface, A/D Converter, ADC0831 ⚠		1
U3	201511-000	IC, Digital, 74HC244, Buffer ⚠		4
U4	202120-001	IC, Linear, LM2940, Regulator, 5V		1
U5	200485-002	IC, Linear, LM324N, Op Amp, Quad		1
U6	202043-000	IC, Interface, 509A, Analog Multiplexer, 4 Channel ⚠	A-C	3
	202043-000	IC, Interface, 509A, Analog Multiplexer, 4 Channel ⚠	D-L	1
U7	201588-000	IC, Digital, 74HC74, D-Type Flip-Flop ⚠		1
U8		(Same as U3)		
U9	202078-003	IC, Digital, TLC1541, 10-Bit Converter ⚠		1
U10	202079-000	IC, Digital, NMC9306NE, EEROM ⚠		1
U11	202072-000	IC, Linear, Voltage/Frequency Converter, LM331M		1
U12	200487-000	IC, Linear, LF353, Op Amp, Dual, 18V ⚠		1
U13	200254-009	IC, Linear, LF355BN, Op Amp		1

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5-7 Ref	Part Number	Description (continued from previous page)	Use Code	Qty
U14	202020-007	Oscillator, High Speed, Hybrid Clock, 8MHz		2
U15	804230-503	IC, Digital, HD637B01Y0P, System Microcomputer		1
U16	201387-000	IC, Linear, ULN2003, Transistor Array		1
U17		(Same as U3)		
U18	201486-000	IC, Linear, LF442, Op Amp, Dual, JFET	A-D, F,H,J, L	2
U19	201611-000	IC, Digital, 74HC221, Dual, One-Shot		1
U20	804230-605	IC, Digital, HD637B01YOC, Defib/ECG Microcomputer		1
U21		(Same as U18)	A-D, F,H,J, L	
	201486-000	IC, Linear, LF442, Op Amp, Dual, JFET	E,G,I, K	1
U22	804290-00	IC, Gate Array, No Fade		1
U23	804298-05	IC, Hybrid, Timing		1
U24	804292-03	IC, Hybrid, Charge Control		1
U25	201654-000	IC, Digital, 7528, Dual Buffer D/A		1
U26	201214-002	IC, Linear, LF444ACN, Quad, Op Amp		1
U27	201732-000	IC, Digital, 6264LP15, RAM, 8 x 8k		1
U28		(Same as U14)		
U29	202080-000	IC, Digital, 74HC240N, Inverting		1
U30	201126-000	IC, Linear, 3525A, PWM Modulator		1
U31		(Same as U3)		
U32	201699-000	IC, Digital, 74C914, CMOS Trigger		2
U33	200359-003	IC, Linear, MC1404U5, Voltage Reference		1
U34	202139-000	IC, TDA1170D, CRT Deflection		1
U35-38	202116-001	Optocoupler, Phototransistor, IL11, 6 Lead		4
U39		(Same as U32)		
U40		(Same as U6)	A-C	
	201743-001	IC, Interface, 509, Analog Multiplexer, 4 Channel	D-L	2
U41	804293-03	IC, Hybrid, Custom, Preamp		1
U42	201658-000	IC, Interface, DG211CJ, Analog Switch, SPST		1
U43		(Same as U6)	A-C	

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5-7 Ref	Part Number	Description (continued from previous page)	Use Code	Qty
		(Same as U40)	D-L	
U44	200933-000	IC, Linear, Voltage Reference Diode, LM336BZ, 2.5V, TO-92		1
U45	202119-000	IC, Linear, LM675, Op Amp		1
XU18	200675-020	**Socket**, IC, DIP	E,G,I, K	1
VSP1	200324-016	**Voltage Surge Protector**, Gas, B2-H100, 8-10.3kV/2pF		1
VSP2-6	200324-010	**Voltage Surge Protector**, Gas, B1-A230, 270V/1pF		5
2	202221-007	**Adhesive**, Hot Melt (Not shown)	G-L	A/R
3	202091-033	**Heat Sink**, Defibrillator Charger (Used on Q25A, Q25B)		1
4	202091-052	**Heat Sink**, Power Supply, With Insulator (Used on Q3)		1
5	201797-003	**Insulator**, Silipad, Transistor, 0.437 L x 0.312 W, TO-220 (Used on Q25A, Q25B)		2
6	201199-100	**Nut**, Hex, 4-40 x 0.188 W x 0.063 T (Used on Q3, Q25A, Q25B)		2
7	200536-008	**Retainer**, Cable Tie, Nylon, 0.1 W x 5.5 L (Used on U15, U20)		2
8	201345-001	**Retainer**, Fuse Clip, 3AG, PCB (Used on F1)		2
9	200476-760	**Screw**, Pan Head, 4-40 x 0.250 L (Used on Q3)		1
10	200476-536	**Screw**, Pan Head, 4-40 x 0.250 L (Used with Upper Preamp Shield)	I-L	1
11	200476-762	**Screw**, Pan Head, 4-40 x 0.375 L (Used on Q25A, Q25B)		1
12	804242-14	**Shield**, Preamp, Upper (Used with U41)	I-L	1
13	202054-000	**Socket**, 0.07, 64-Contact (Used on U15,20)		2
14	201765-097	**Tape**, Adhesive-Foam, 0.25 W x 0.06 T (Used with Upper Preamp Shield)	I-L	A/R
15	201802-004	**Tape**, Foil (Used on T3)		A/R
16	200624-005	**Tubing**, Teflon, 200°C, 20 AWG (Used with CR52)	G-L	A/R
17	202413-000	**Washer**, Lock, Split, #4 x 0.195 OD/0.025 T (Used on Q3, Q25A, Q25B)		2
18	200431-849	**Washer**, Shoulder, Nylon, #4 x 0.115 ID x 0.060 T (Used on Q3, Q25A, Q25B)		4
19	202412-000	**Wire**, Bus, 22 AWG (Used on L1, L2, not shown)	B-L	A/R
20	202448-000	**Wire**, Solid, Teflon, Type E, 24 AWG	G-L	A/R
21	202412-001	**Wire**, Solid, Uninsulated, 24 AWG (Used on T3)		A/R

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5-8 Ref	Part Number	Description	Use Code	Qty
A2	804202-02	**Chart/Pacer PCB Assembly** ⚠	A	REF
	804202-03	**Chart PCB Assembly** ⚠	B	REF
	804202-04	**Chart/Pacer PCB Assembly** ⚠	C	REF
	804202-05	**Chart PCB Assembly** ⚠	D	REF
	804202-06	**Chart/Pacer PCB Assembly** ⚠	E	REF
	804202-07	**Chart PCB Assembly** ⚠	F	REF
	804202-08	**Chart/Pacer PCB Assembly** ⚠	G	REF
	804202-09	**Chart PCB Assembly** ⚠	H	REF
	804202-12	**Chart/Pacer PCB Assembly** ⚠	I	REF
	804202-13	**Chart PCB Assembly** ⚠	J	REF
C1	201628-012	**Capacitor**, 0.1µF/50V, 5%	A,C,E,G,I	17
	201628-012	**Capacitor**, 0.1µF/50V, 5%	B,D,F,H,J	11
C2	200901-026	**Capacitor**, 220pF/50V, 5%		1
C3, 4		(Same as C1)		
C5	201628-018	**Capacitor**, 1.0µF/50V	A,C,E,G,I	2
	201628-018	**Capacitor**, 1.0µF/50V	B,D,F,H,J	1
C6-8		(Same as C1)		
C9	200901-046	**Capacitor**, 0.01µF/50V, 5%		1
C10		(Same as C1)		
C11	201628-006	**Capacitor**, 1.0µF/50V, 5%		3
C12		(Same as C1)		
C13	202102-024	**Capacitor**, Electrolytic, 330µF/25V, 20%	A,C,E,G,I	2
	202102-024	**Capacitor**, Electrolytic, 330µF/25V, 20%	B,D,F,H,J	1
C14		(Same as C11)		
C15, 16	200901-134	**Capacitor**, 22pF/50V, 10%		2
C17, 18		(Same as C1)		
C19-21	202102-031	**Capacitor**, Electrolytic, 4700µF/25V		3
C22-24	201628-000	**Capacitor**, 1000pF/50V, 5%	A	6
	201628-000	**Capacitor**, 1000pF/50V, 5%	C,E,G,I	7
C25		(Same as C5)	A,C,E,G,I	

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5-8 Ref	Part Number	Description (continued from previous page)	Use Code	Qty
C26	200500-038	Capacitor, 10µF/25V, 20%		1
C27	200901-022	Capacitor, 100pF/50V, 5%	A,C,E,G,I	2
	200901-022	Capacitor, 100pF/50V, 5%	B,D,F,H,J	1
C28		(Same as C11)		
C29		(Same as C1)		
C30, 31		(Same as C1)	A,C,E,G,I	
C32		(Same as C13)	A,C,E,G,I	
C33		(Same as C1)	A,C,E,G,I	
C34, 35	200274-026	Capacitor, 100pF/500V, 5%	A,C,E,G,I	2
C37	200049-039	Capacitor, 0.1µF/50V, 20%	A,C,E,G,I	2
C38		(Same as C1)	A,C,E,G,I	
C39	201628-014	Capacitor, 0.22µF/50V, 5%	A,C,E,G,I	5
C40		(Same as C1)	A,C,E,G,I	
C41		(Same as C39)	A,C,E,G,I	
C42	200893-046	Capacitor, 1.0µF/50V, 10%	A,C	1
	200893-046	Capacitor, 1.0µF/50V, 10%	E,G,I	2
C43-45		(Same as C22)	A,C,E,G,I	
C46-48		(Same as C39)	A,C,E,G,I	
C49		(Same as C37)	A,C,E,G,I	
C50		(Same as C1)	A,C,E,G,I	
C51	200893-042	Capacitor, 0.47µF/50V, 10%	A,C,E,G,I	1
C52		(Same as C27)	A,C,E,G,I	
C53	202159-050	Capacitor, Electrolytic, 150µF/400V	A,C,E,G,I	1
C54		(Same as C42)	E,G,I	
C55		(Same as C22)	C,E,G,I	
CR1	200971-000	Diode, 1N914B, 8ns, PIV 75	A,C	11
	200971-000	Diode, 1N914B, 8ns, PIV 75	E,G,I	12
	200971-000	Diode, 1N914B, 8ns, PIV 75	B,D,F,H	3
	200971-000	Diode, 1N914B, 8ns, PIV 75	J	4
CR2	202136-003	Diode, UF4004		2
CR3		(Same as CR1)		

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5-8 Ref	Part Number	Description (continued from previous page)	Use Code	Qty
CR4	200177-053	Diode, Zener, P6KE82A, 1mA/600W	A,C,E,G,I	1
CR5		(Same as CR1)		
CR6		(Same as CR2)		
CR7	202136-006	Diode, UF4007	A,C,E,G,I	1
CR8-11		(Same as CR1)	A,C,E,G,I	
CR12	200086-027	Diode, Zener, 1N4112, 13.2mA/18V	A,C,E,G,I	1
CR13-16		(Same as CR1)	A,C,E,G,I	
CR17	201225-004	Diode, Schottky, SB160, 1A	A,C,E,G,I	1
CR18		(Same as CR1)	E-J	
J21	202128-100	Connector, Straight, 3-Contact	A,C,E,G,I	1
J22	201191-219	Connector, PCB, 14-Contact		1
J23	201191-222	Connector, PCB, 26-Contact		1
J24	201191-221	Connector, PCB, 20-Contact		1
J37	201504-004	Connector, Terminal, PCB		1
Q1	202155-000	Transistor, FET, IRFD9010, 4 Contact		1
Q2	200585-001	Transistor, FET, VN0106N3, TO-92	A,C,E,G,I	6
	200585-001	Transistor, FET, VN0106N3, TO-92	B,D,F,H,J	1
Q3	200994-001	Transistor, FET, RFP12P08, TO-220AB		1
Q4		(Same as Q2)	A,C,E,G,I	
Q5	201696-000	Transistor, MOSFET, IRF540, TO-220	A,C,E,G,I	1
Q6		(Same as Q2)	A,C,E,G,I	
Q7	201738-001	Transistor, FET VP0106N3, TO-92	A,C,E,G,I	1
Q8	202203-001	Transistor, TMOS, MTP2P50, TO-220	A,C,E,G,I	1
Q9	201569-000	Transistor, FET, IRF830, TO-220	A,C,E,G,I	1
Q10	200942-001	Transistor, NPN, PN2222A, TO-92	A,C,E,G,I	2
Q11	202164-000	Transistor, FET, MTD2N50	A,C,E,G,I	1
Q12-14		(Same as Q2)	A,C,E,G,I	
Q15		(Same as Q10)	A,C,E,G,I	
R1	201527-000	Wire, Jumper, 0Ω, 1/4W	A-H	3

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5-8 Ref	Part Number	Description (continued from previous page)	Use Code	Qty
	201527-000	Wire, Jumper, 0Ω, 1/4W	I,J	2
R2	200054-317	Resistor, 20kΩ, 1/8W, 1%, RN55C	A,C,E,G,I	6
	200054-317	Resistor, 20kΩ, 1/8W, 1%, RN55C	B,D,F,H,J	5
R3	200054-363	Resistor, 60.4kΩ, 1/8W, 1%, RN55C		1
R4	200054-345	Resistor, 39.2kΩ, 1/8W, 1%, RN55C	A,C,E,G,I	2
	200054-345	Resistor, 39.2kΩ, 1/8W, 1%, RN55C	B,D,F,H,J	1
R5, 6	200054-353	Resistor, 47.5kΩ, 1/8W, 1%, RN55C	A,C,E,G,I	3
	200054-353	Resistor, 47.5kΩ, 1/8W, 1%, RN55C	B,D,F,H,J	2
R7	200054-326	Resistor, 24.9kΩ, 1/8W, 1%, RN55C		1
R8	200054-480	Resistor, 1MΩ, 1/8W, 1%, RN55C	A,C,E,G,I	5
	200054-480	Resistor, 1MΩ, 1/8W, 1%, RN55C	B,D,F,H,J	2
R9	200054-257	Resistor, 4.75kΩ, 1/8W, 1% RN55C	A	6
	200054-257	Resistor, 4.75kΩ, 1/8W, 1% RN55C	C,E,G,I	5
	200054-257	Resistor, 4.75kΩ, 1/8W, 1% RN55C	B,D,F,H,J	4
R10	200527-028	Potentiometer, 10kΩ, 1/2W, 20%		1
R11	200054-193	Resistor, 1kΩ, 1/8W, 1%, RN55C	A	1
	200054-273	Resistor, 6.98kΩ, 1/8W, 1%, RN55C	F,J	1
	200054-267	Resistor, 6.04kΩ, 1/8W, 1%, RN55C	E,G,I	1
	200054-250	Resistor, 4.02kΩ, 1/8W, 1%, RN55C	C	1
	200054-259	Resistor, 4.99kΩ, 1/8W, 1%, RN55C	D	1
R12	200054-193	Resistor, 1kΩ, 1/8W, 1%, RN55C	A,C,E,G,I	8
	200054-193	Resistor, 1kΩ, 1/8W, 1%, RN55C	B,D,J	6
	200054-193	Resistor, 1kΩ, 1/8W, 1%, RN55C	F,H	7
R13		(Same as R8)		
R14	200471-024	Resistor, 10Ω, 1/2W, 5%		1
R15	200054-401	Resistor, 150kΩ, 1/8W, 1%, RN55C	A,C,E,G,I	7
	200054-401	Resistor, 150kΩ, 1/8W, 1%, RN55C	B,D,F,H,J	1
R16	200054-288	Resistor, 10kΩ, 1/8W, 1%, RN55C	A,C,E,G,I	12
	200054-288	Resistor, 10kΩ, 1/8W, 1%, RN55C	B,D,F,H,J	5
R17		(Same as R2)		
R18	200054-222	Resistor, 2kΩ, 1/8W, 1%, RN55C	A,C,E,G,I	4
	200054-222	Resistor, 2kΩ, 1/8W, 1%, RN55C	B,D,F,H,J	1

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5-8 Ref	Part Number	Description (continued from previous page)	Use Code	Qty
R19		(Same as R12)		
R20		(Same as R2)		
R21	200054-114	Resistor, 150Ω, 1/8W, 1%, RN55C		1
R22, 23	200054-097	Resistor, 100Ω, 1/8W, 1%, RN55C	B,D,F,H,J	3
	200054-097	Resistor, 100Ω, 1/8W, 1%, RN55C	A	5
	200054-097	Resistor, 100Ω, 1/8W, 1%, RN55C	C,E,G,I	6
R24		(Same as R16)		
R25	200216-002	Resistor, 0.2Ω, 1W, 1%		1
R26		(Same as R9)		
R27		(Same as R1)		
R28		(Same as R9)		
R29		(Same as R12)		
R30	200054-355	Resistor, 49.9kΩ, 1/8W, 1%, RN55C	A,C,E,G,I	5
	200054-355	Resistor, 49.9kΩ, 1/8W, 1%, RN55C	B,D,F,H,J	4
R31		(Same as R16)		
R32		(Same as R30)		
R33	200054-290	Resistor, 10.5kΩ, 1/8W, 1%, RN55C		1
R34		(Same as R1)	A-H	
R35		(Same as R16)		
R36, 37		(Same as R30)		
R38		(Same as R9)		
R39		(Same as R2)		
R40		(Same as R12)		
R41		(Same as R15)	A,C,E,G,I	
R42	200054-139	Resistor, 274Ω, 1/8W, 1%, RN55C	A,C,E,G,I	1
R43	200054-309	Resistor, 16.5kΩ, 1/8W, 1%, RN55C	A,C,E,G,I	1
R44	200216-004	Resistor, 0.301Ω, 1W, 1%	A,C,E,G,I	1
R45	200470-016	Resistor, 4.7Ω, 1/4W, 5%	A,C,E,G,I	1
R46		(Same as R16)	A,C,E,G,I	
R47	200054-165	Resistor, 511Ω, 1/8W, 1%, RN55C	A,C,E,G,I	2
	200054-165	Resistor, 511Ω, 1/8W, 1%, RN55C	B,D,F,H,J	1
R48		(Same as R22)	A,C,E,G,I	

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5-8 Ref	Part Number	Description (continued from previous page)	Use Code	Qty
R49		(Same as R2)		
R50		(Same as R22)	A,C,E,G,I	
R51	200054-306	Resistor, 15.4kΩ, 1/8W, 1%, RN55C	A,C,E,G,I	2
	200054-306	Resistor, 15.4kΩ, 1/8W, 1%, RN55C	B,D,F,H,J	1
R52, 53		(Same as R12)		
R54	200054-069	Resistor, 51.1Ω, 1/8W, 1%, RN55C		1
R55		(Same as R22)		
R56		(Same as R16)		
R57	200054-451	Resistor, 499kΩ, 1/8W, 1%, RN55C	A,C,E,G,I	6
R58	201155-003	Resistor, 1000MΩ, 1W, 10%	A,C,E,G,I	1
R59, 60	200578-072	Resistor, 100Ω, 1W, 5%	A,C,E,G,I	2
R61, 62		(Same as R15)	A,C,E,G,I	
R63		(Same as R51)	A,C,E,G,I	
R64	200471-063	Resistor, 430Ω, 1/2W, 5%	A,C,E,G,I	2
R65		(Same as R16)	A,C,E,G,I	
R66		(Same as R8)	A,C,E,G,I	
R67		(Same as R18)	A,C,E,G,I	
R68	200054-347	Resistor, 41.2kΩ, 1/8W, 1%, RN55C	A,C,E,G,I	1
R69		(Same as R5)	A,C,E,G,I	
R70		(Same as R30)	A,C,E,G,I	
R71		(Same as R15)	A,C,E,G,I	
R72		(Same as R8)	A,C,E,G,I	
R73	200054-422	Resistor, 249kΩ, 1/8W, 1%, RN55C	A,C,E,G	3
	200054-422	Resistor, 249kΩ, 1/8W, 1%, RN55C	I	2
R74	200054-512	Resistor, 2.21MΩ, 1/8W, 1%, RN55C	A,C,E,G,I	3
R75		(Same as R73)	A,C,E,G	
	200054-468	Resistor, 750kΩ, 1/8W, 1%, RN55C	I	1
R76, 77		(Same as R74)	A,C,E,G,I	
R78	200054-541	Resistor, 4.42MΩ, 1/8W, 1%, RN55C	A,C,E,G,I	2
R79	200054-491	Resistor, 1.33MΩ, 1/8W, 1%, RN55C	A,C,E,G,I	1
R80		(Same as R16)	A,C,E,G,I	
R81		(Same as R15)	A,C,E,G,I	

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5-8 Ref	Part Number	Description (continued from previous page)	Use Code	Qty
R82		(Same as R18)	A,C,E,G,I	
R83	200054-438	**Resistor**, 365kΩ, 1/8W, 1%, RN55C	A,C,E,G,I	2
R84	200054-406	**Resistor**, 169kΩ, 1/8W, 1%, RN55C	A,C,E,G,I	1
R85		(Same as R83)	A,C,E,G,I	
R86	200054-470	**Resistor**, 787kΩ, 1/8W, 1%, RN55C	A,C,E,G,I	1
R87		(Same as R57)	A,C,E,G,I	
R88		(Same as R4)	A,C,E,G,I	
R89		(Same as R15)	A,C,E,G,I	
R90		(Same as R16)	A,C,E,G,I	
R91		(Same as R73)	A,C,E,G,I	
R92		(Same as R64)	A,C,E,G,I	
R93	200054-350	**Resistor**, 44.2kΩ, 1/8W, 1%, RN55C	A,C,E,G,I	1
R94	200054-254	**Resistor**, 4.42kΩ, 1/8W, 1%, RN55C	A,C,E,G,I	1
R95		(Same as R78)	A,C,E,G,I	
R96, 97		(Same as R16)	A,C,E,G,I	
R98		(Same as R8)	A,C,E,G,I	
R99		(Same as R16)	A,C,E,G,I	
R100	200054-249	**Resistor**, 3.92kΩ, 1/8W, 1%, RN55C	A,C,E,G,I	1
R101		(Same as R12)	A,C,E,G,I	
R102	200054-380	**Resistor**, 90.9kΩ, 1/8W, 1%, RN55C	A,C,E,G,I	1
R103		(Same as R18)	A,C,E,G,I	
R104	200054-411	**Resistor**, 191kΩ, 1/8W, 1%, RN55C	A,C,E,G,I	2
R105		(Same as R2)	A,C,E,G,I	
R106		(Same as R104)	A,C,E,G,I	
R107	200054-034	**Resistor**, 22.1Ω, 1/8W, 1%, RN55C	A,C,E,G,I	1
R108		(Same as R9)	A	
		(Same as R22)	C,E,G,I	
R109		(Same as R9)	A,C,E,G,I	
R110	200471-124	**Resistor**, 150kΩ, 1/2W, 5%	A,C,E,G,I	2
R111	200054-005	**Resistor**, 11Ω, 1/8W, 1%	A,C,E,G,I	1
R112		(Same as R47)	A,C,E,G,I	
R113		(Same as R110)	A,C,E,G,I	

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5-8 Ref	Part Number	Description (continued from previous page)	Use Code	Qty
R114-117		(Same as R57)	A,C,E,G,I	
R118	200054-349	Resistor, 43.2kΩ, 1/8W, 1%	E,G,I	1
R119		(Same as R12)	E-J	
RN1	200043-065	Resistor Network, 8 x 10kΩ, 1.5W, 2%, 16 Contact	A,C,E,G,I	2
	200043-065	Resistor Network, 8 x 10kΩ, 1.5W, 2%, 16 Contact	B,D,F,H,J	1
RN2, 3	200043-040	Resistor Network, 8 x 1kΩ, 1.5W, 2%, 16 Contact		2
RN4	200422-089	Resistor Network, 9 x 10kΩ, 1.25W, 2%, 10 Contact		1
RN5	201240-018	Resistor Network, 4 x 100kΩ, 0.33W, 5%, 8 Contact	A,C,E,G,I	1
RN6	201240-012	Resistor Network, 4 x 10kΩ, 0.33W, 5%, 8 Contact	A,C,E,G,I	1
RN7		(Same as RN1)	A,C,E,G,I	
RN9	201240-006	Resistor Network, 4 x 1kΩ, 0.33W, 5%, 8 Contact	A,C,E,G,I	1
RV100, 101	201251-157	Varistor, 390V, 92J, 4500A	A,C,E,G,I	2
T1	804281-01	Transformer, Power Supply	A,C,E,G,I	1
U1	200669-002	IC, Linear, LM339, Comparator ⚠	A,C,E,G,I	3
	200669-002	IC, Linear, LM339, Comparator ⚠	B,D,F,H	2
	200669-002	IC, Linear, LM339, Comparator ⚠	J	1
U2	200673-007	IC, Linear, RCG, 78L12, TO-92 ⚠	A,C,E,G,I	2
	200673-007	IC, Linear, RCG, 78L12, TO-92 ⚠	B,D,F,H,J	1
U3	201387-000	IC, ULN2003		1
U4	202020-007	IC, Digital, Oscillator ⚠		1
U5	202165-000	IC, Digital, 74HC7266 ⚠		1
U6	202074-000	IC, Digital, 74HC595 ⚠		1
U7	200345-000	IC, Digital, LM393, Op Amp		1
U8	804230-405	IC, Digital, HD637B01Y0P, Microcomputer ⚠		1
U9	201609-000	IC, Digital, 74HC138, Decoder ⚠		1
U10	202053-001	IC, Digital, DS1216, Smartwatch (Used only if U29 is 202143-006; if U29 is 202227-000, U10 is not installed)	A,C,E,G,I,J	1

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5-8 Ref	Part Number	Description (continued from previous page)	Use Code	Qty
U11	201594-002	IC, Digital, ADC0804		1
U12	804280-00	IC, Gate Array, Recorder Printhead		1
U13	202050-000	IC, Linear, 3843N, Pulse-Width Regulator	A,C,E,G,I	1
U14	201705-000	IC, Digital, 74HC14, Schmitt Inverter ⚠2		1
U15-18	202116-001	IC, Linear, IL-11, Opto-Isolator	A,C,E,G,I	4
U19		(Same as U2)	A,C,E,G,I	
U20	200445-000	IC, Linear, LM392B, Voltage Reference, TO-92	A,C,E,G,I	1
U21		(Same as U1)	A,C,E,G,I	
U22	200854-006	IC, Linear, LM334Z, Adjustable Current Source ⚠2	A,C,E,G,I	1
U23		(Same as U1)	A,C,E,G,I	
U24	200472-000	IC, Digital, 4538BC, Dual Multivibrator ⚠2	A,C,E,G,I	1
U25	200487-000	IC, Linear, LF353, Dual Op Amp	A,C,E,G,I	1
U26	200359-003	IC, Linear, MC1404U5, Voltage Reference	A,C,E,G,I	1
U27	200485-002	IC, Linear, LM324N, Quad Op Amp	A,C,E,G,I	1
U28	202160-000	IC, Linear, TL431CLP, Voltage Reference	A,C,E,G,I	1
U29	202227-000	IC, Digital, DS1242, Smartwatch and RAM ⚠2		1
	202143-006	Alternate part: IC, Digital, 256k RAM⚠2 (Plugs into U10; not used if U29 is 202227-000)		1
VSP1	200324-016	**Voltage Surge Protector**, 8-10.3kV, 2pF	A,C,E,G,I	1
2	202221-007	**Adhesive**, Hot Melt (Used on C19,20,21,53,R58, not shown)	C-J	A/R
3	202091-053	**Heat Sink** (Used on Q3,5)		2
4	202091-052	**Heat Sink**, Dual TO-220 (Used on Q8,9)	A,C,E,G,I	1
5	201199-100	**Nut**, Hex, 4-40 x 0.188 W x 0.063 T (Used on Q8,9)	A,C,E,G,I	2
6	200476-762	**Screw**, Pan Head, 4-40 x 0.375 L (Used on Q8,9)	A,C,E,G,I	1
7	202413-000	**Washer**, Lock, #4 x 0.195 OD/0.25 T (Used on Q8,9)	A,C,E,G,I	1
8	200431-849	**Washer**, Nylon Shoulder (Used on Q8,9)	A,C,E,G,I	2

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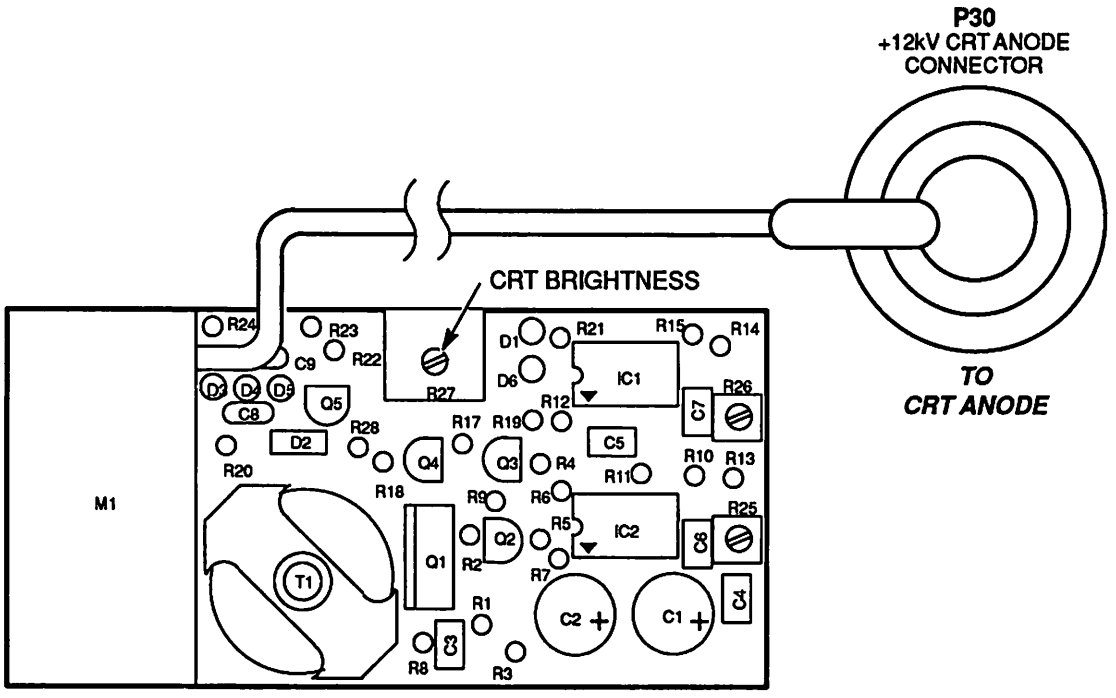
5–10 Ref	Part Number	Description	Use Code	Qty
A3	804296–05	**Anode Power Supply Assembly** ⚠ (AS1 on System PCB Assembly, Figure 5–7, page 5–41), Not repairable		REF



A3

Figure 5–10 Anode Power Supply
Part Number 804296
(Sheet 1 of 1)

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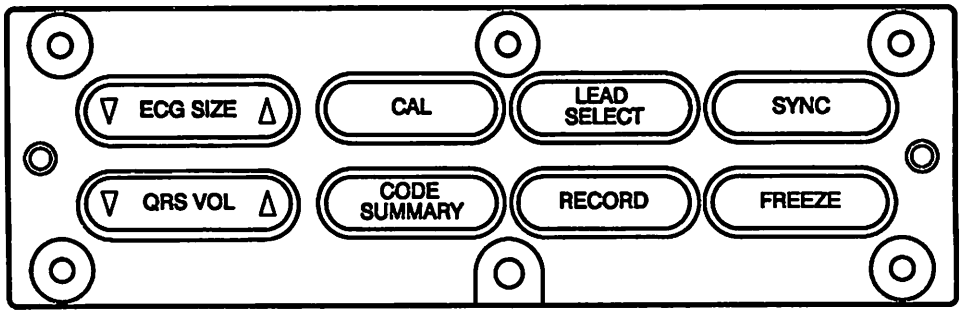
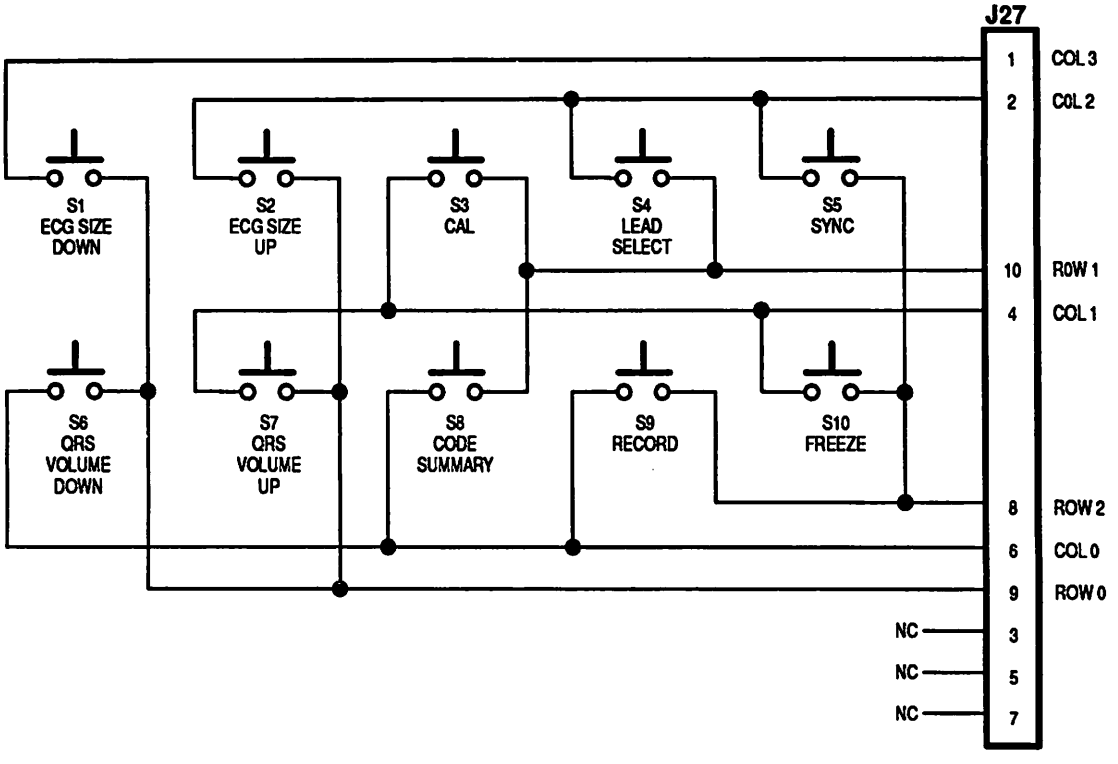
5–11 Ref	Part Number	Description	Use Code	Qty
A4	804277–01	Main Control Panel Assembly, French		REF
	804277–02	Main Control Panel Assembly, German		REF
	804277–03	Main Control Panel Assembly, Spanish		REF
	804277–04	Main Control Panel Assembly, English		REF





A4

Figure 5–11 Main Control Panel Assembly
Part Number 804277
(Sheet 1 of 1)

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5-12 Ref	Part Number	Description	Use Code	Qty
A5	804196-01	**Battery Indicator Panel** (Used in final assemblies with no pacemaker)		REF
	804196-05	**Pacer Control Panel, English**		REF
	804196-06	**Pacer Control Panel, French**		REF
	804196-07	**Pacer Control Panel, German**		REF
	804196-08	**Pacer Control Panel, Spanish**		REF
	804196-09	**Pacer Control Panel, International**		REF

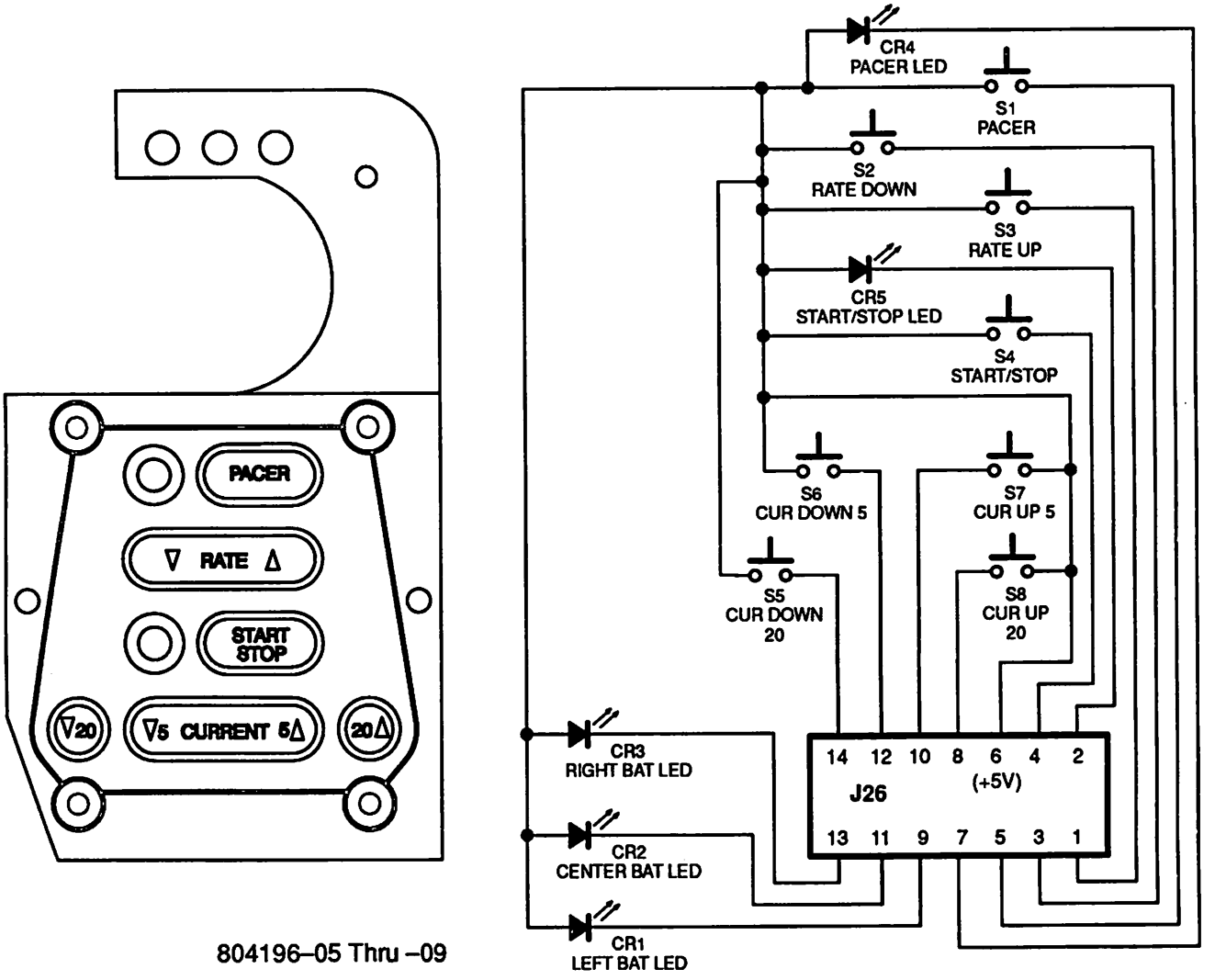

Figure 5–12 Pacer Control/Battery Indicator Panel Assembly
Part Number 804196
(Sheet 1 of 2)

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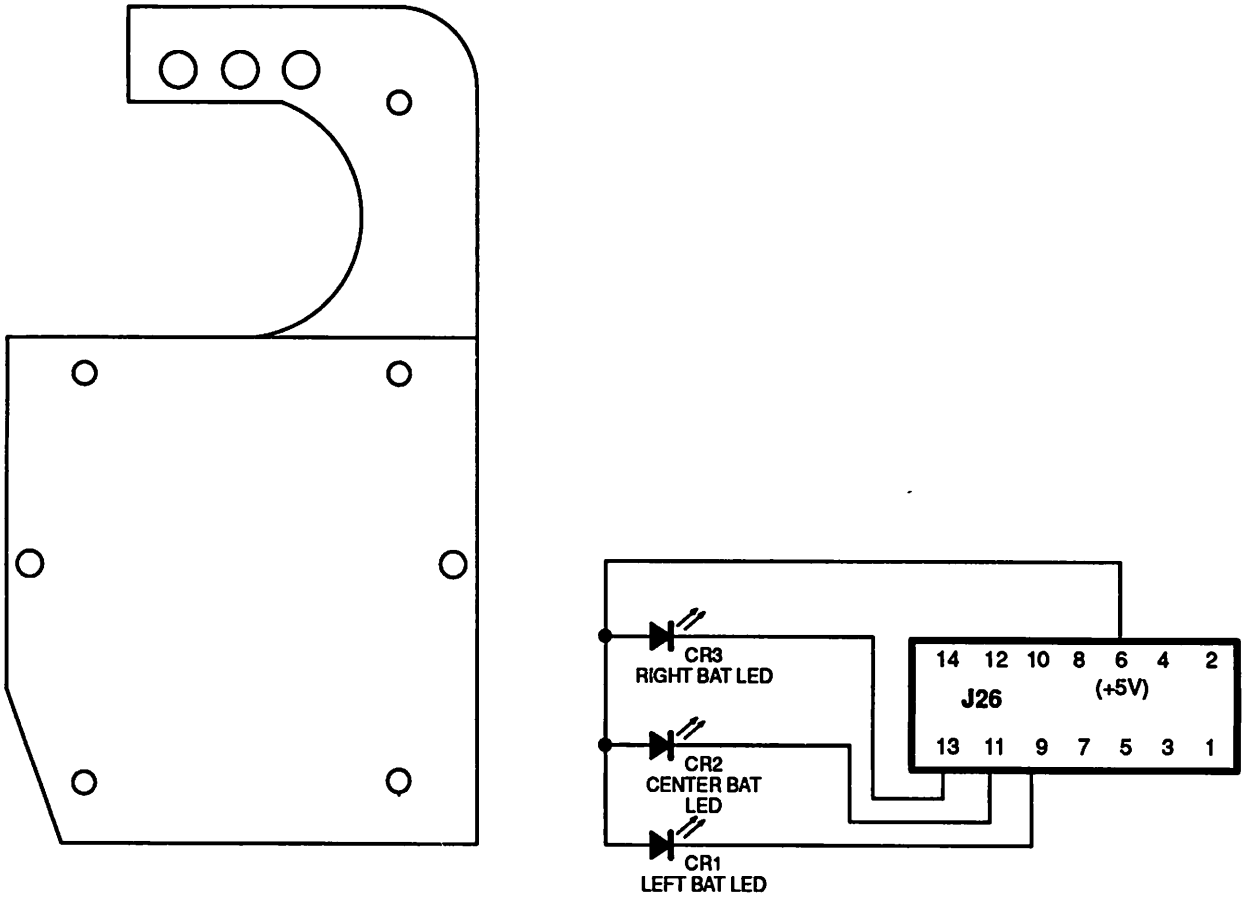

804196–01

A5

Figure 5-12 Pacer Control/Battery Indicator Panel Assembly
Part Number 804196
(Sheet 2 of 2)

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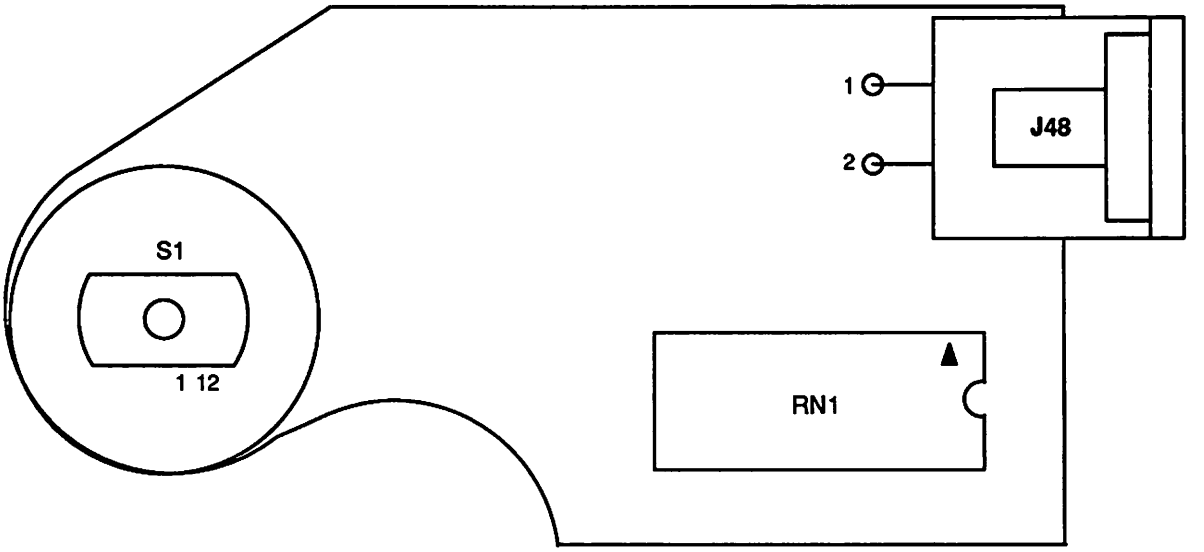
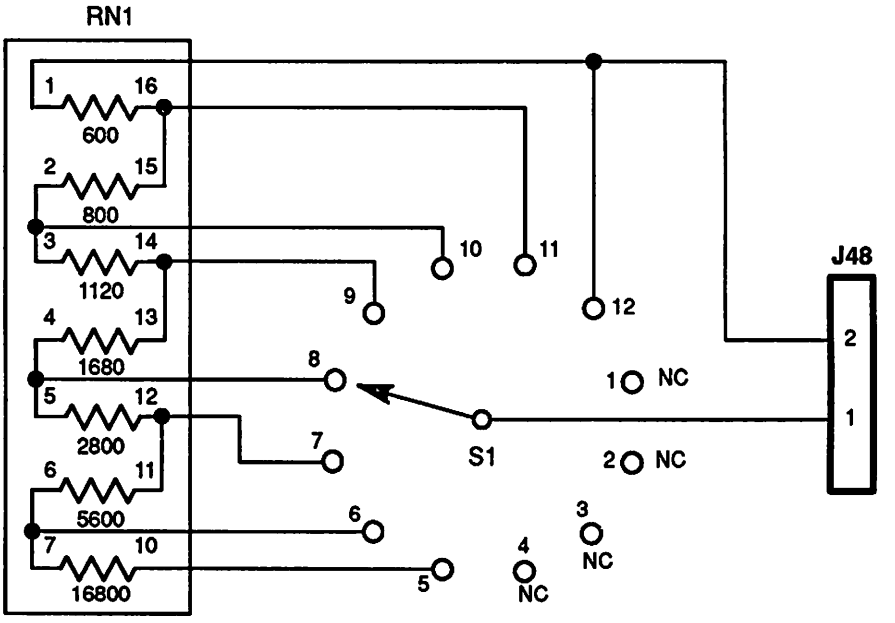
5–13 Ref	Part Number	Description	Use Code	Qty
A6	804258-02	Energy Select PCB (Used in A8)		REF





A6

Figure 5–13 Energy Select PCB Assembly
Part Number 804258
(Sheet 1 of 1)

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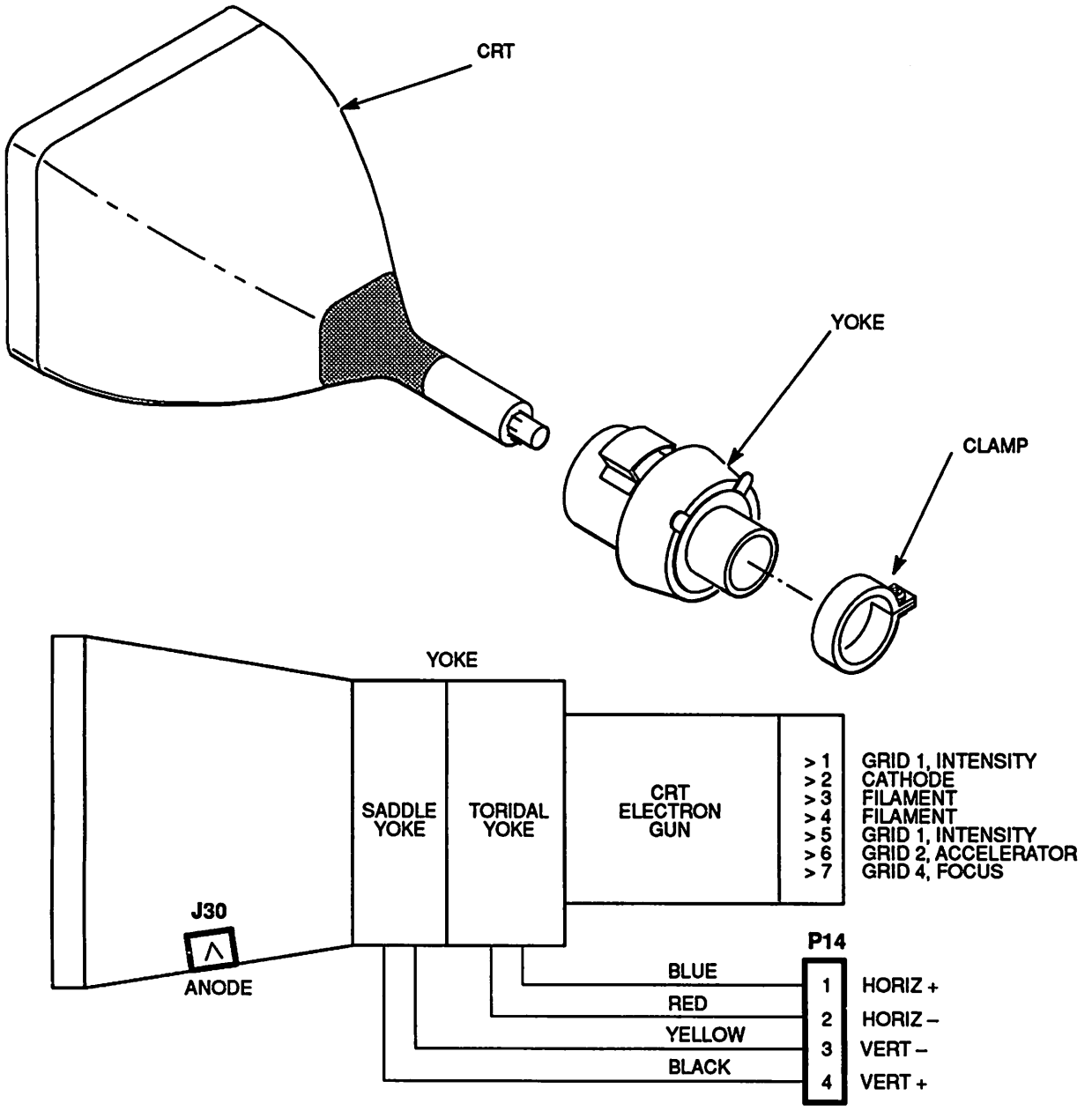
5–14 Ref	Part Number	Description	Use Code	Qty
A11	805180-00	CRT Assembly (Not repairable)		REF



A11

Figure 5–14 CRT Assembly
Part Number 805180
(Sheet 1 of 1)

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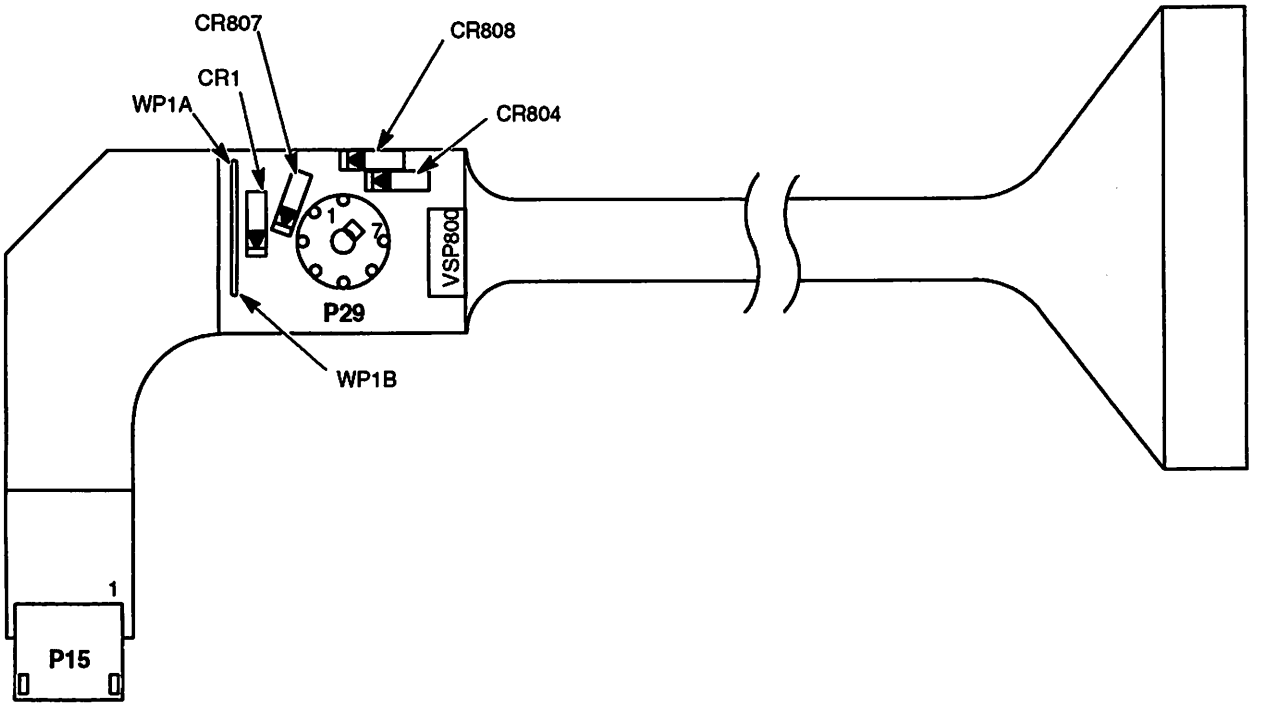
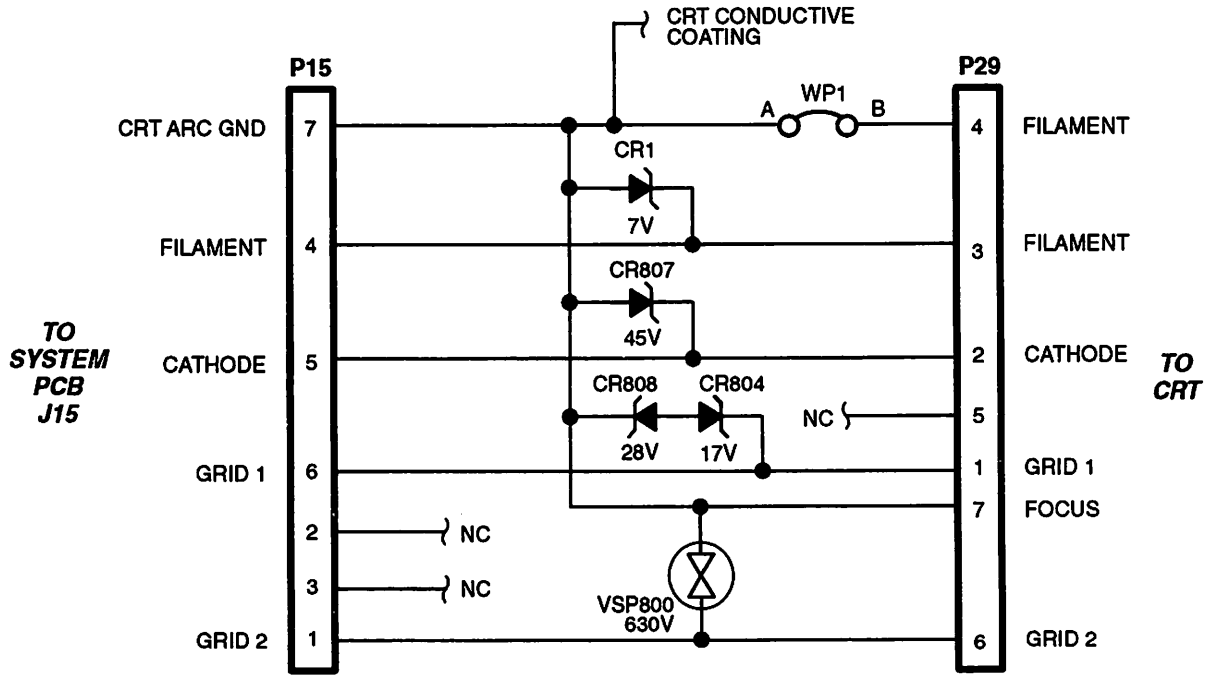
5–15 Ref	Part Number	Description	Use Code	Qty
A12	805078-01	**CRT PFC Assembly** (Not repairable)		REF





A12

Figure 5–15 CRT PFC Assembly Part Number 805078 (Sheet 1 of 1)

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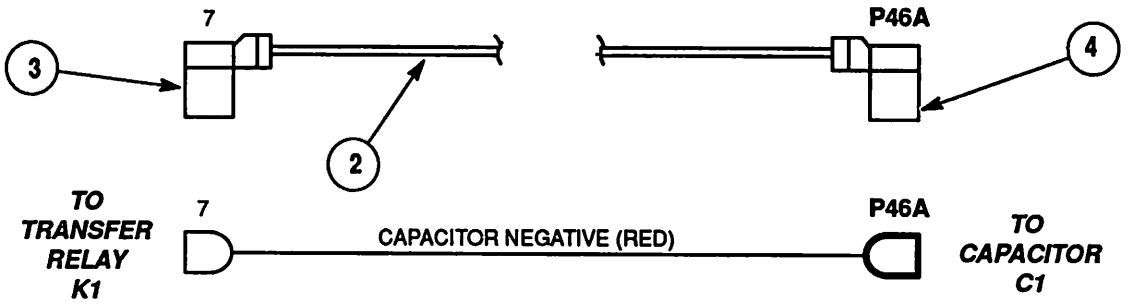
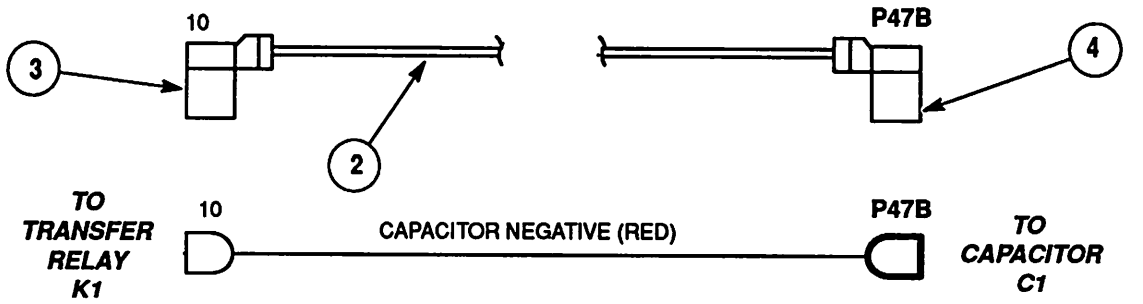
5-16 Ref	Part Number	Description	Use Code	Qty
W1	805115-01	**Capacitor Negative-Relay Wire Harness**		REF
2	202190-000	**Cable,** High Voltage, UL/CSA, 105°C (221°F), 10kV, 0.0312 OD		A/R
3	200514-006	**Terminal,** Receptacle, 90°, Quick Disconnect, 22-18 AWG		1
4	200514-000	**Terminal,** Receptacle, 90°, Quick Disconnect, 22-18 AWG		1



W1

Figure 5–16 Capacitor Negative-Relay Wire Harness
Part Number 805115-01

5-17 Ref	Part Number	Description	Use Code	Qty
W2	805115-02	**Capacitor Positive-Relay Wire Harness**		REF
2	202190-000	**Cable,** High Voltage, UL/CSA, 105°C (221°F), 10kV, 0.0312 OD		A/R
3	200514-006	**Terminal,** Receptacle, 90°, Quick Disconnect, 22-18 AWG		1
4	200514-000	**Terminal,** Receptacle, 90°, Quick Disconnect, 22-18 AWG		1



W2

Figure 5–17 Capacitor Positive-Relay Wire Harness
Part Number 805115-02

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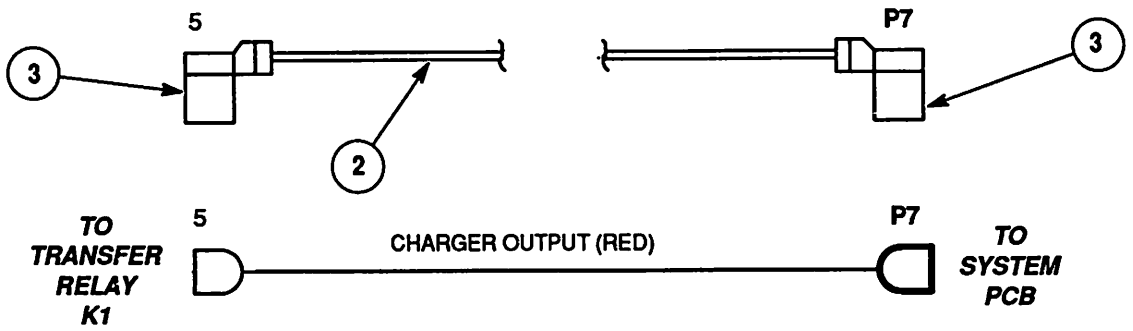
5-18 Ref	Part Number	Description	Use Code	Qty
W3	805115-00	**Charger Output Wire Harness**		REF
2	202190-000	**Cable,** High Voltage, UL/CSA, 105°C (221°F), 10kV, 0.0312 OD		A/R
3	200514-006	**Terminal,** Receptacle, 90°, Quick Disconnect, 22-18 AWG		2



W3

Figure 5–18 Charger Output Wire Harness
Part Number 805115-00

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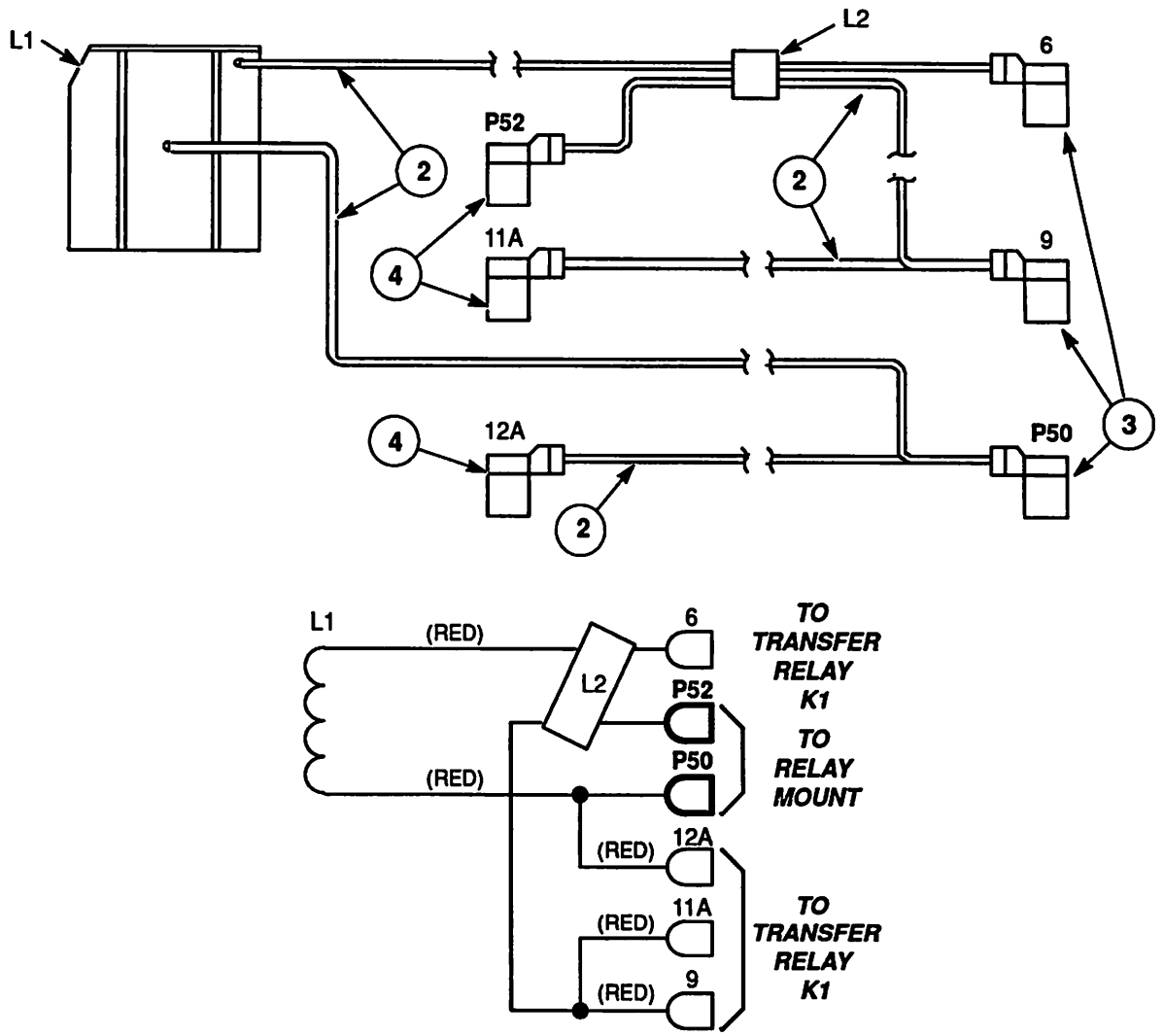
5-19 Ref	Part Number	Description	Use Code	Qty
W4	805115-14	**Inductor/Relay Wire Harness**		REF
L1	804212-03	**Inductor,** Waveshaping		1
L2	200808-028	**Inductor,** Bead, Ferrite, 0.075 ID, 0.250 OD, 0.400 L		1
2	202190-000	**Cable,** High Voltage, UL/CSA, 105°C (221°F), 10kV, 0.0312 OD		A/R
3	200514-010	**Terminal,** Receptacle, 90°, Quick Disconnect, 22-18 AWG		3
4	200514-006	**Terminal,** Receptacle, 90°, Quick Disconnect, 22-18 AWG		3



W4

Figure 5–19 Inductor/Relay Wire Harness
Part Number 805115-14

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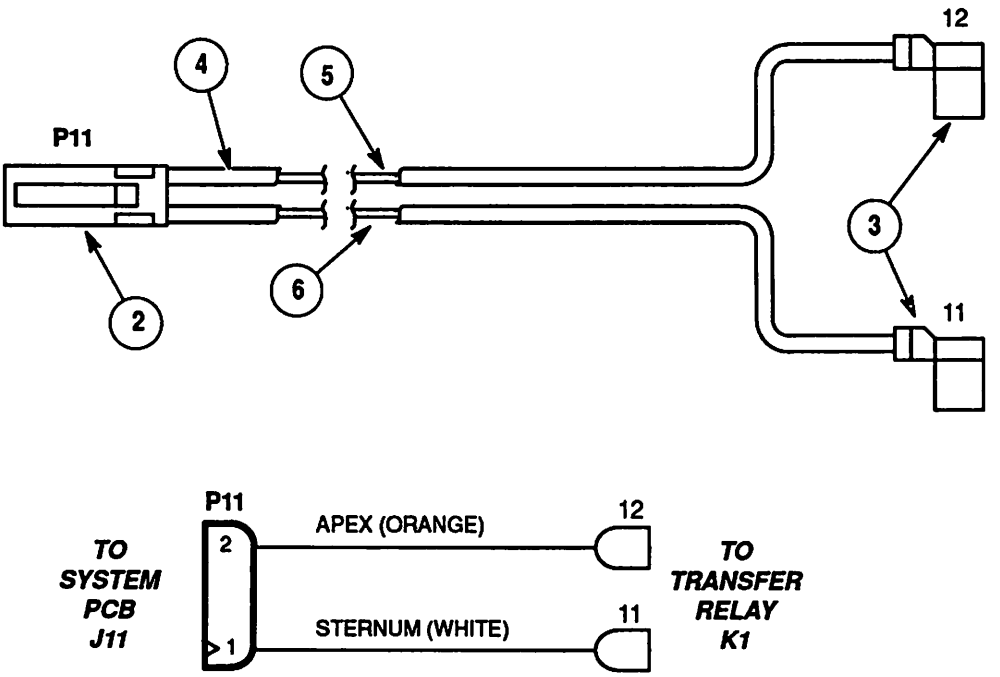
5-20 Ref	Part Number	Description	Use Code	Qty
W5	805115-03	**QUIK-LOOK Apex and Sternum Wire Harness**	REF	REF
2	202125-024	**Receptacle Assembly**, Polarized/Latching, Single-Row, 26-22 AWG, 2 Contact	1	1
3	200514-006	**Terminal**, Receptacle, 90°, Quick Disconnect, 22-18 AWG	2	2
4	201756-010	**Tubing**, PVC, Clear, #12, 0.085 ID	A/R	A/R
5	201535-021	**Wire**, Semirigid, PVC, 300V, 22 AWG, Orange	A/R	A/R
6	201535-027	**Wire**, Semirigid, PVC, 300V, 22 AWG, White	A/R	A/R



W5

Figure 5–20 QUIK-LOOK, Apex, Sternum Wire Harness
Part Number 805115-03

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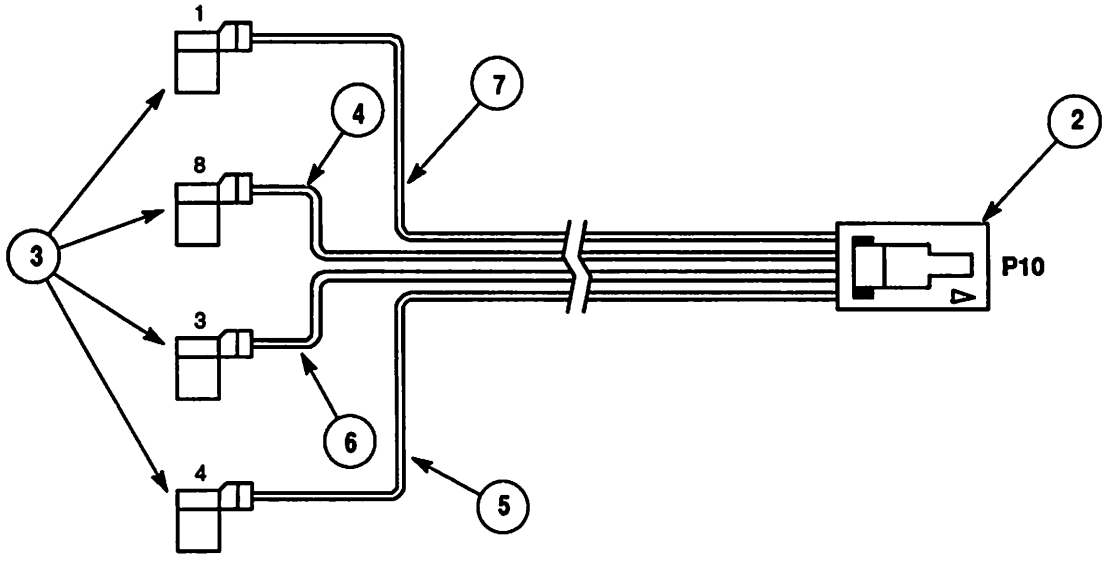
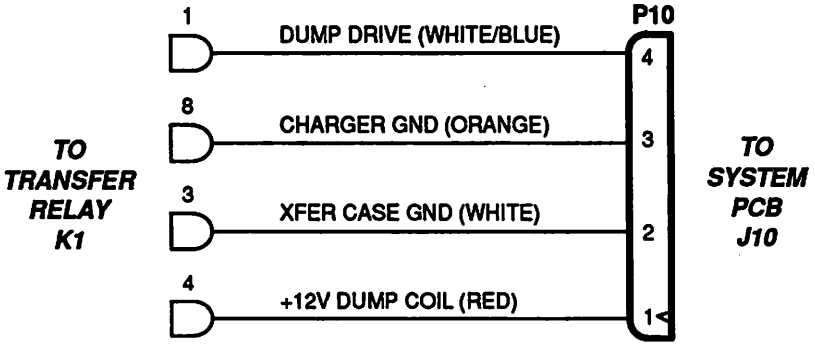
5-21 Ref	Part Number	Description	Use Code	Qty
W6	805115-04	System PCB-Relay Wire Harness		REF
2	202125-026	Receptacle Assembly, Polarized/Latching, Single-Row, 26-22 AWG, 4 Contact		1
3	200514-006	Terminal, Receptacle, 90°, Quick Disconnect, 22-18 AWG		4
4	201535-021	Wire, Semirigid, PVC, 300V, 22 AWG, Orange		A/R
5	201535-019	Wire, Semirigid, PVC, 300V, 22 AWG, Red		A/R
6	201535-027	Wire, Semirigid, PVC, 300V, 22 AWG, White		A/R
7	201535-031	Wire, Semirigid, PVC, 300V, 22 AWG, White/Blue		A/R





W6

Figure 5–21 System PCB-Relay Wire Harness
Part Number 805115-04

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5-22 Ref	Part Number	Description	Use Code	Qty
W7	805115-15	**Auxiliary Power Connector-System PCB Wire Harness**		REF
L5,L6	200808-027	**Inductor,** Bead, Ferrite, 0.187 ID, 0.365 OD, 0.400 L		2
2	804286-10	**Receptacle,** Contacts, Wires, Potted		1
3	202125-024	**Receptacle Assembly,** Polarized/Latching, Single-Row, 26-22 AWG, 2 Contact		2
4	202125-026	**Receptacle Assembly,** Polarized/Latching, Single-Row, 26-22 AWG, 4 Contact		1
5	200276-093	**Terminal,** Lug, Ring Tongue, #6, 16-14 AWG		1
6	200267-030	**Terminal,** Receptacle, Disconnect, Insulated, 16-14 AWG		1

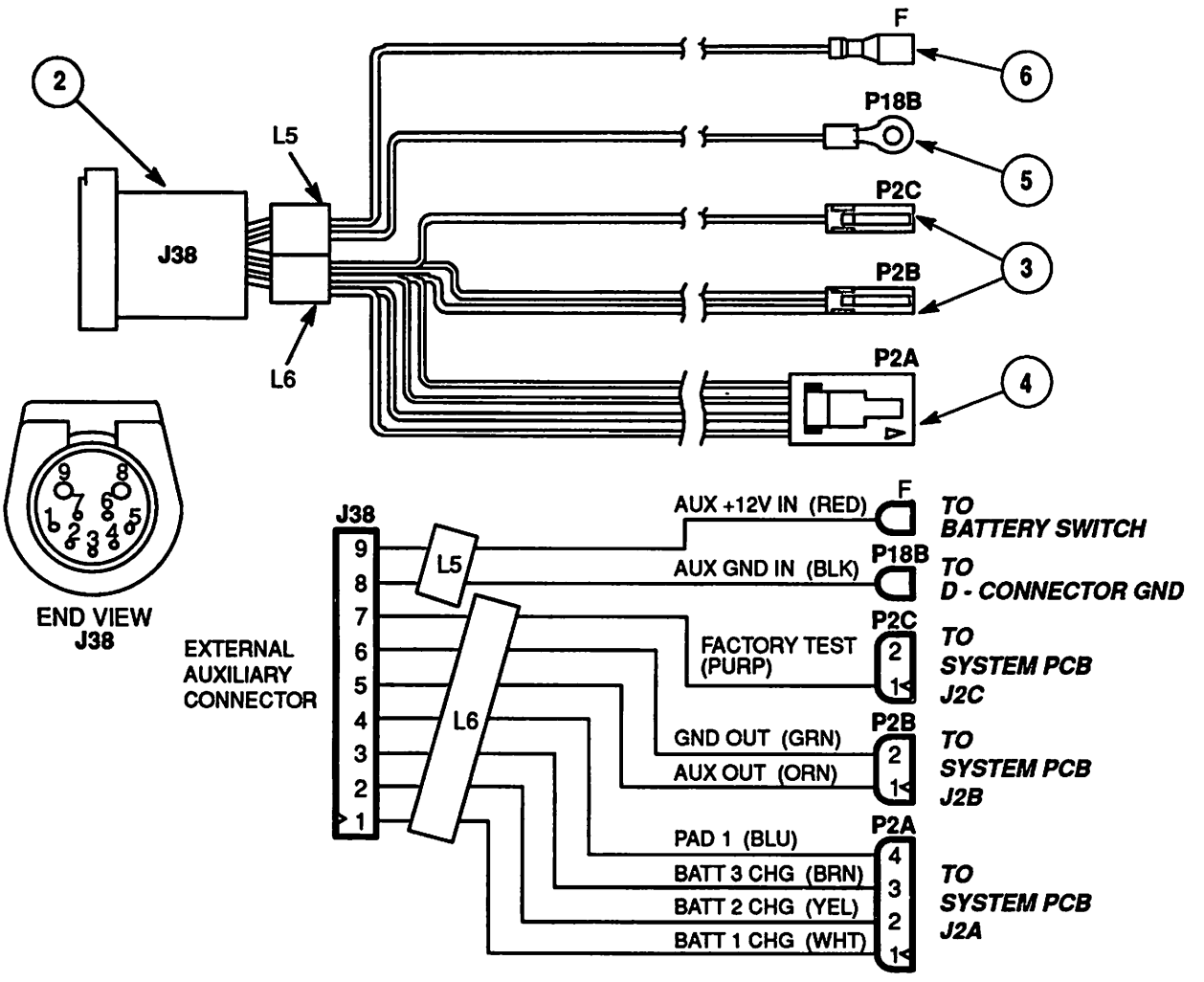

Figure 5–22 Auxiliary Power Connector-System PCB Wire Harness Part Number 805115-15

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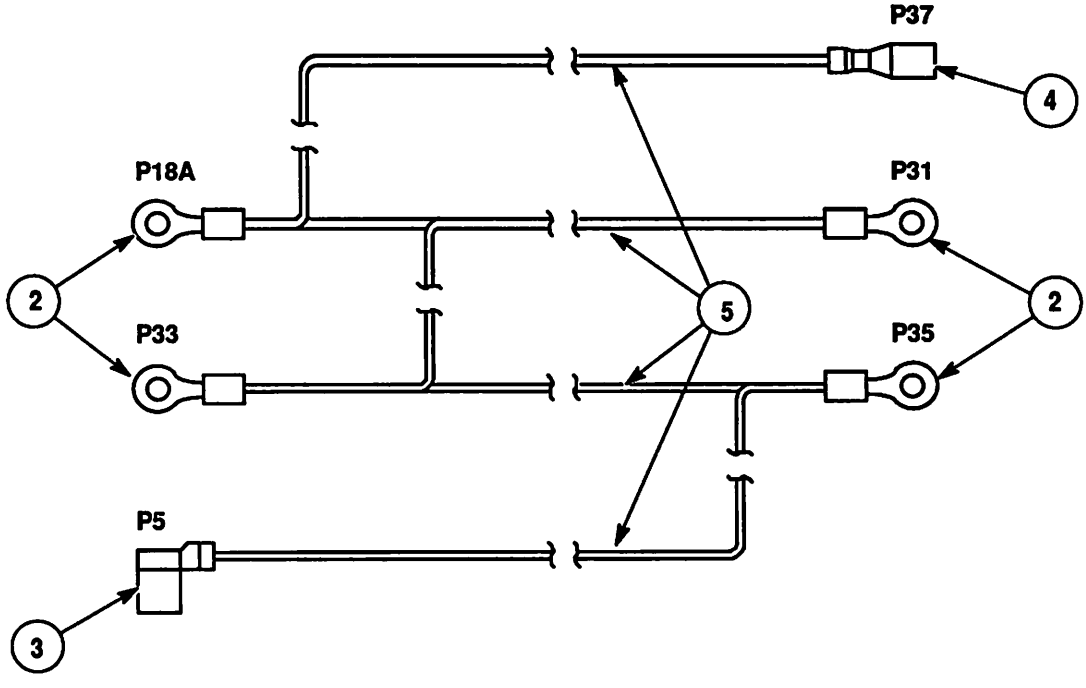
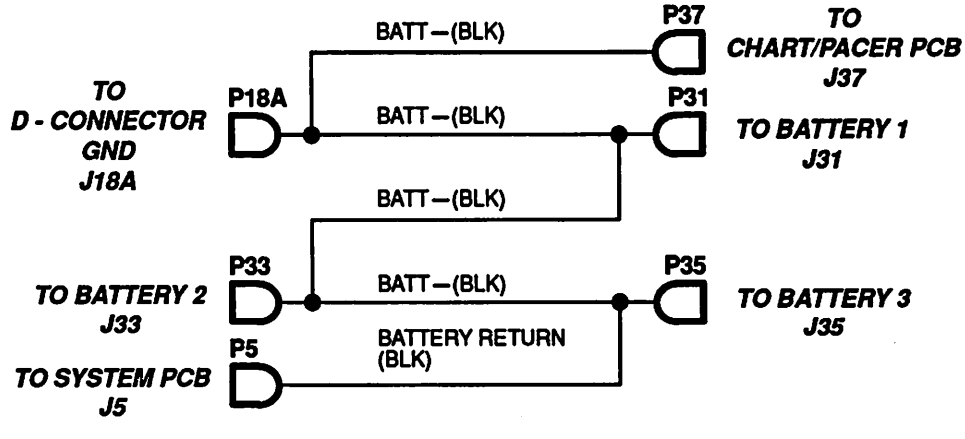
5-23 Ref	Part Number	Description	Use Code	Qty
W8	805115-09	**Battery-Chart/Pacer PCB Wire Harness**		REF
2	200276-162	**Terminal**, Lug, Ring Tongue, 12-10 AWG, No. 4		4
3	200514-008	**Terminal**, Receptacle, 90°, Quick Disconnect, 16-14 AWG		1
4	200267-030	**Terminal**, Receptacle, Disconnect, Insulated, 16-14 AWG		1
5	201535-093	**Wire**, Semirigid, PVC, 300V, 16 AWG, Black		A/R





W8

Figure 5–23 Battery-Chart/Pacer PCB Wire Harness
Part Number 805115-09

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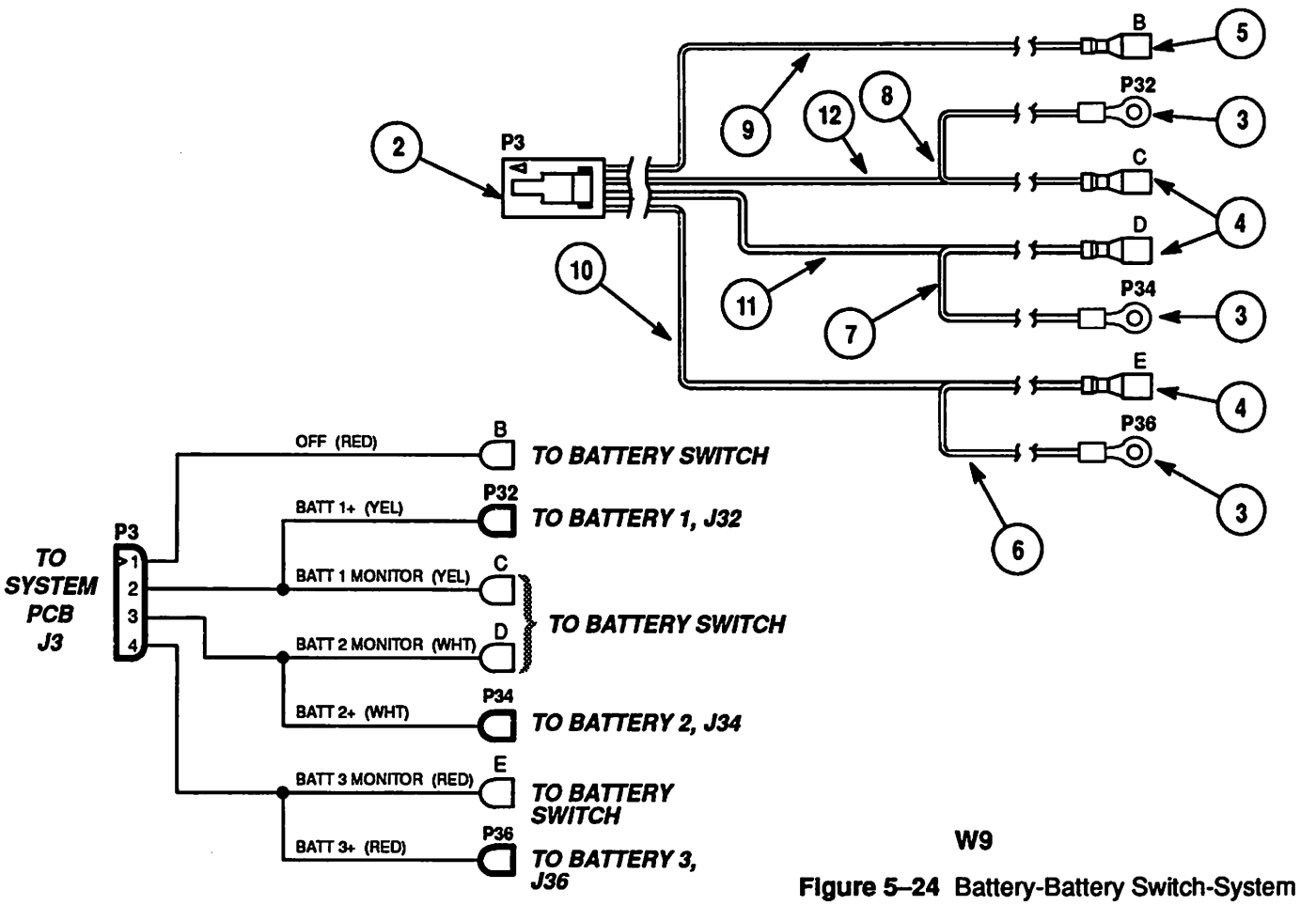
5-24 Ref	Part Number	Description	Use Code	Qty
W9	805115-10	**Battery-Battery Switch-System PCB Wire Harness**		REF
2	202125-026	**Receptacle Assembly**, Polarized/Latching, Single-Row, 26-22 AWG, 4 Contact		1
3	200276-093	**Terminal**, Lug, Ring Tongue, #6, 16-14 AWG		3
4	200267-030	**Terminal**, Receptacle, Disconnect, Insulated, 16-14 AWG		3
5	200267-026	**Terminal**, Receptacle, Disconnect, Insulated, 22-18 AWG		1
6	201535-094	**Wire**, Semirigid, PVC, 300V, 16 AWG, Red		A/R
7	201535-102	**Wire**, Semirigid, PVC, 300V, 16 AWG, White		A/R
8	201535-097	**Wire**, Semirigid, PVC, 300V, 16 AWG, Yellow		A/R
9	201535-021	**Wire**, Semirigid, PVC, 300V, 22 AWG, Orange		A/R
10	201535-019	**Wire**, Semirigid, PVC, 300V, 22 AWG, Red		A/R
11	201535-027	**Wire**, Semirigid, PVC, 300V, 22 AWG, White		A/R
	201535-022	**Wire**, Semirigid, PVC, 300V, 22 AWG, Yellow		A/R



W9

Figure 5–24 Battery-Battery Switch-System PCB Wire Harness Part Number 805115-10

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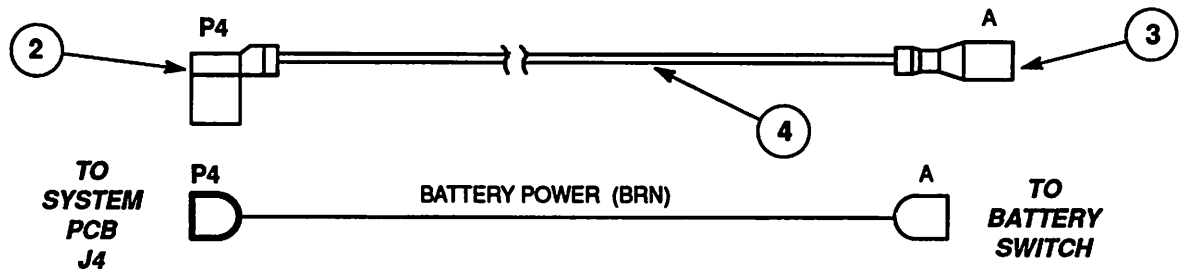
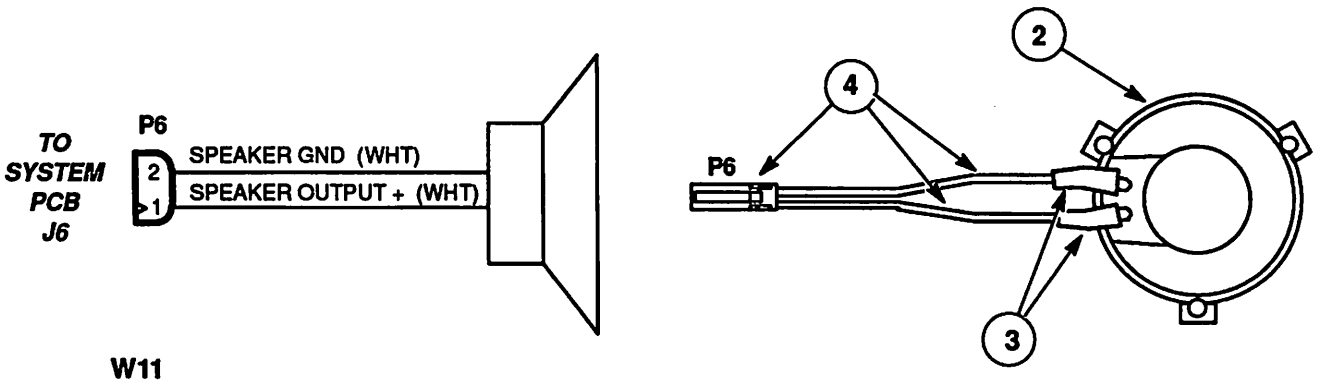
5-25 Ref	Part Number	Description	Use Code	Qty
W10	805115-07	**Battery Switch-System PCB Wire Harness**		REF
2	200514-008	**Terminal**, Receptacle, 90°, Quick Disconnect, 16-14 AWG		1
3	200267-030	**Terminal**, Receptacle, Disconnect, Insulated, 16-14 AWG		1
4	201535-102	**Wire**, Semirigid, PVC, 300V, 16 AWG, White		A/R



W10

Figure 5–25 Battery Switch-System PCB
Wire Harness
Part Number 805115-07

5-26 Ref	Part Number	Description	Use Code	Qty
W11	805115-06	**Speaker-System PCB Wire Harness**		REF
2	201148-020	**Speaker**, Audio, No. 330-4K, 1.87 D		1
3	200283-017	**Tubing**, Heatshrink, 0.125 ID, Black		A/R
4	805115-16	**Wire Harness**, Speaker		1



W11

Figure 5–26 Speaker-System PCB
Wire Harness
Part Number 805115-06

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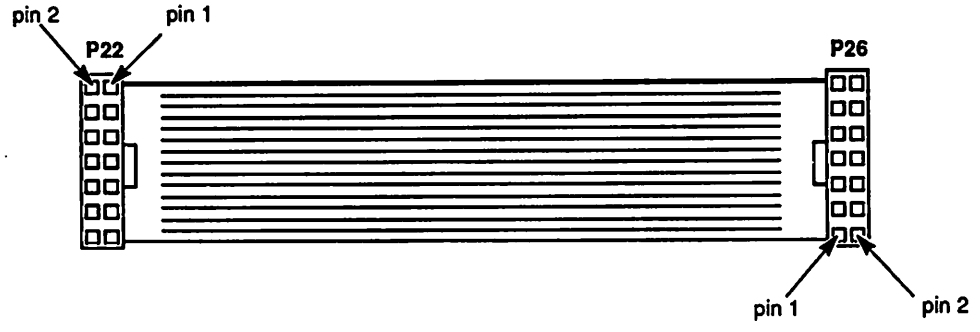
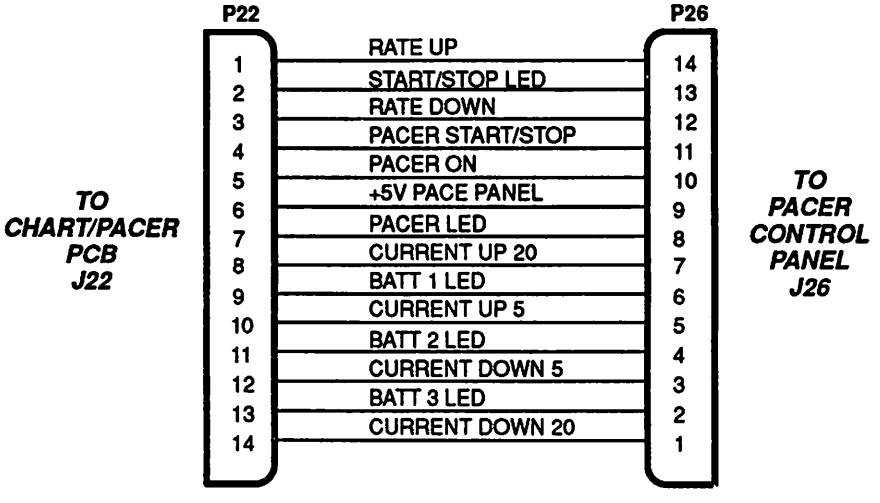
5-27 Ref	Part Number	Description	Use Code	Qty
W12	804249-00	Pacer Cable (not repairable)		REF




P22
P26
TO CHART/PACER PCB J22
TO PACER CONTROL PANEL J26
1 RATE UP 14
2 START/STOP LED 13
3 RATE DOWN 12
4 PACER START/STOP 11
5 PACER ON 10
6 +5V PACE PANEL 9
7 PACER LED 8
8 CURRENT UP 20 7
9 BATT 1 LED 6
10 CURRENT UP 5 5
11 BATT 2 LED 4
12 CURRENT DOWN 5 3
13 BATT 3 LED 2
14 CURRENT DOWN 20 1

W12

Figure 5–27 Pacer Cable
Part Number 804249-00

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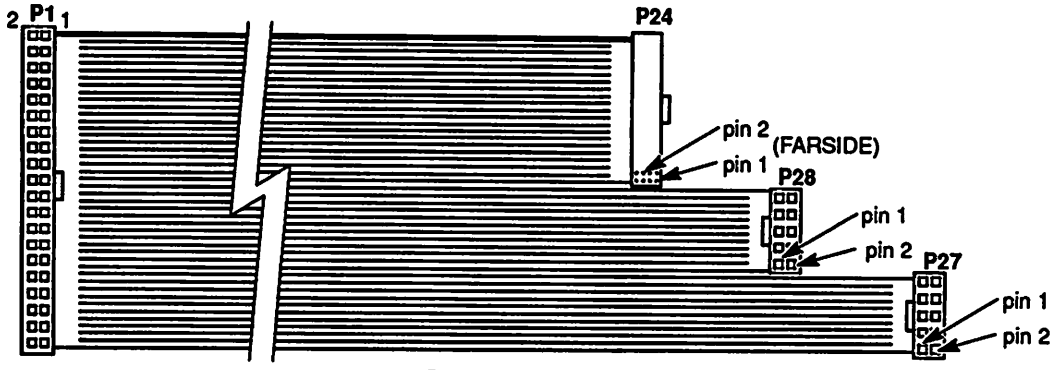
5-28 Ref	Part Number	Description	Use Code	Qty
W13	804252-01	Control Cable (not repairable)		REF



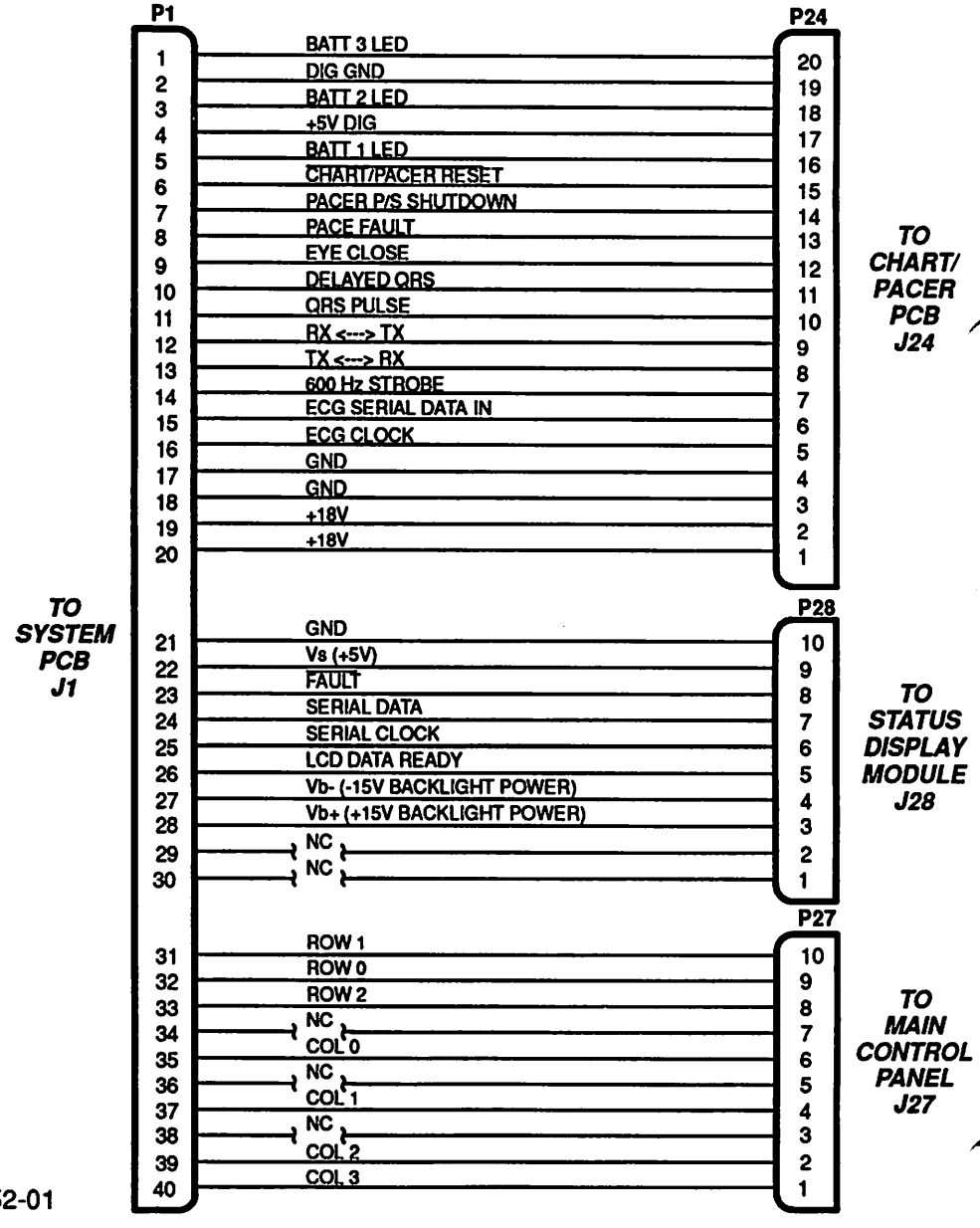


Figure 5–28 Control Cable
Part Number 804252-01

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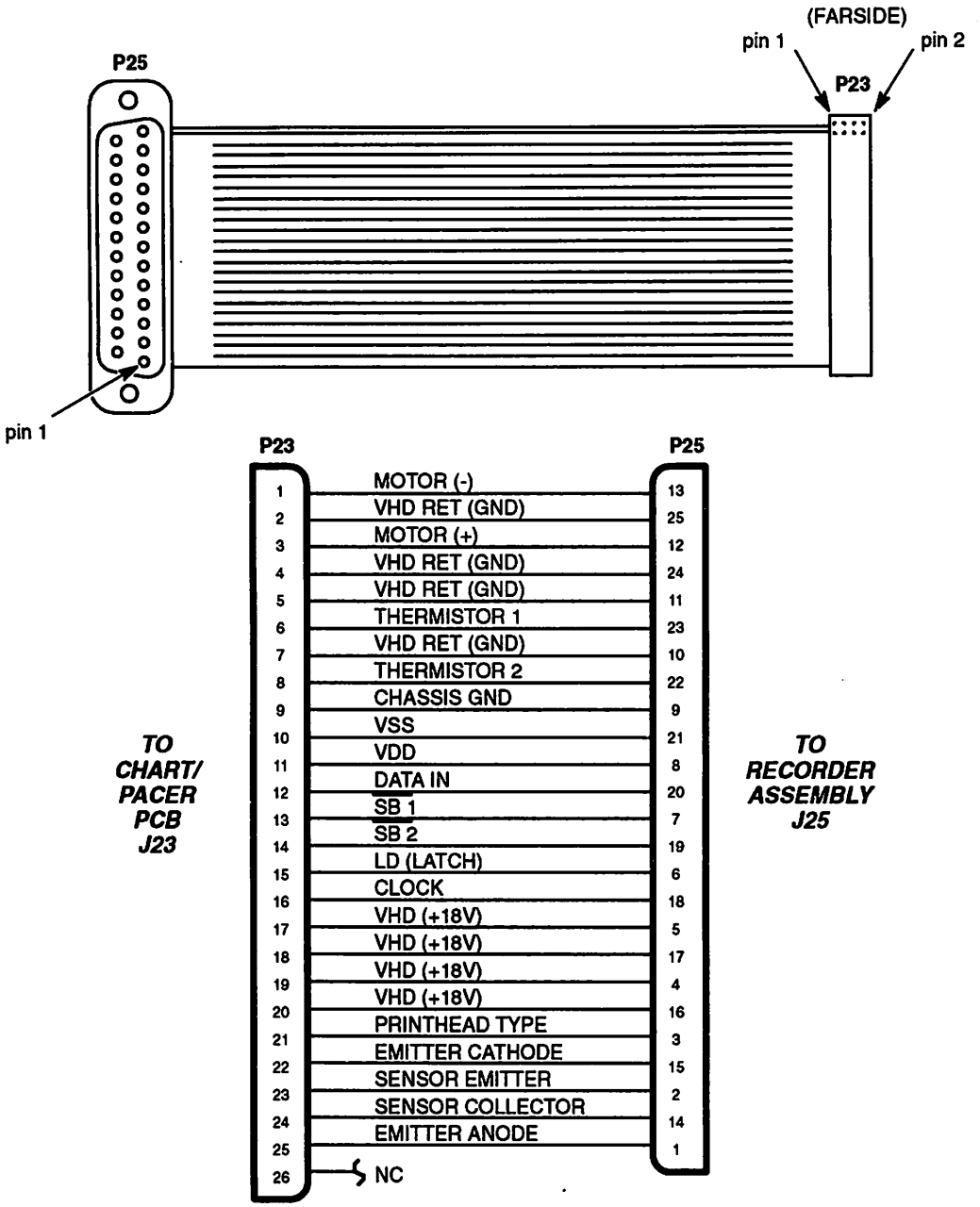
5-29 Ref	Part Number	Description	Use Code	Qty
W14	804253-00	**Recorder Cable** (not repairable)		REF



W14

Figure 5–29 Recorder Cable
Part Number 804253-00

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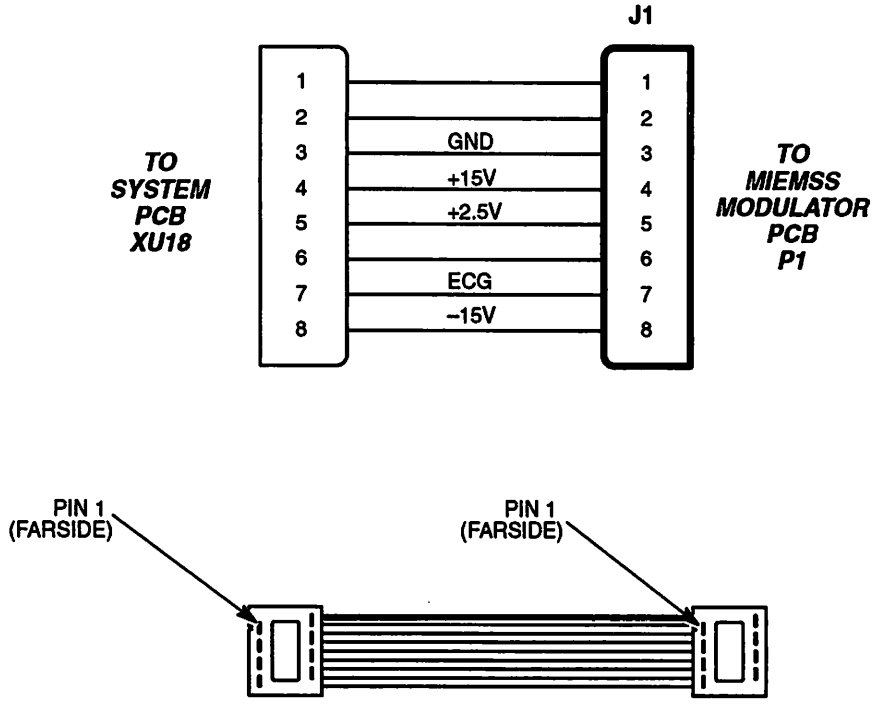
5-30 Ref	Part Number	Description	Use Code	Qty
W15	805628-00	System PCB-MIEMSS PCB Cable (not repairable)		REF



W15

Figure 5–30 System PCB-MIEMSS PCB Cable
Part Number 805628-00

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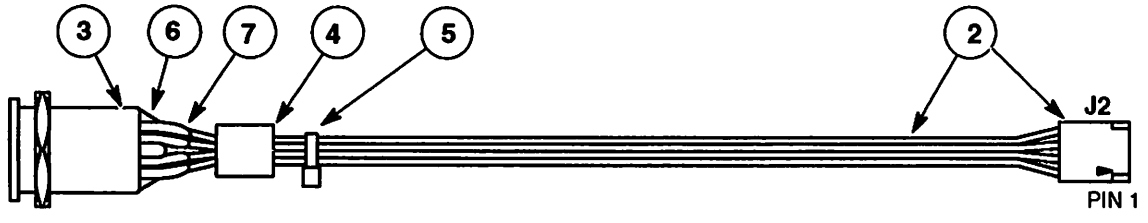
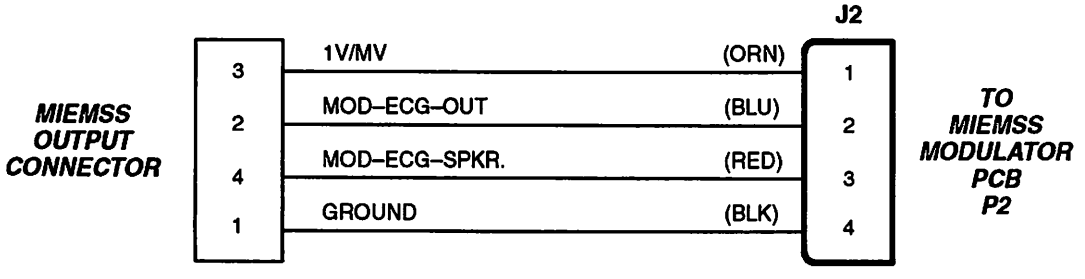
5-31 Ref	Part Number	Description	Use Code	Qty
W16	805629-01	**MIEMSS PCB Output Cable**		REF
J2	200419-021	**Connector,** Receptacle, 4 contact		1
2	805629-02	**Cable Assembly,** Output Modification		1
3	202272-000	**Connector,** Jack, ECG Out		1
4	200808-027	**Inductor,** Ferrite bead		1
5	200536-009	**Retainer,** Cable tie, Nylon, 0.1W x 4.06L		1
6	202257-001	**Sealant,** RTV, Silicone, White		A/R
7	200283-017	**Tubing,** Heatshrink, Black, 0.125 ID		A/R





W16

Figure 5–31 MIEMSS PCB Output Cable
Part Number 805629-00

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5-32 Ref	Part Number	Description	Use Code	Qty
	805600-00	**12 Lead ECG Adapter**, English, AHA	A	REF
	805600-01	**12 Lead ECG Adapter**, English, IEC	B	REF
	805600-02	**12 Lead ECG Adapter**, French, IEC	C	REF
	805600-03	**12 Lead ECG Adapter**, French, AHA	D	REF
	805600-04	**12 Lead ECG Adapter**, German, IEC	E	REF
	805600-05	**12 Lead ECG Adapter**, Spanish, IEC	F	REF
	805600-06	**12 Lead ECG Adapter**, Swedish, IEC	G	REF
2	805598-00	**Bracket**, Switch, 12 Lead ECG Adapter		1
3	200050-014	**Bushing**, Strain Relief, Nylon, 0.250 x 0.156		1
4	200050-022	**Bushing**, Strain Relief, Nylon, 0.300 x 0.156		1
5	805233-01	**Cable**, Adapter		1
6	805601-00	**Cable Assembly**, 12 Lead ECG Adapter, AHA	A,D	1
	805601-01	**Cable Assembly**, 12 Lead ECG Adapter, IEC	B,C,E-G	1
7	805596-01	**Enclosure**, Plastic (Consists of top, bottom, and four screws)		1
8	805223-03	**Extension Shaft**, 12 Lead ECG Adapter, Black		1
9	805223-02	**Extension Shaft**, 12 Lead ECG Adapter, White		1
10	202236-004	**Foot**, Mounting, Rubber, Black		4
11	200126-006	**Knob**, 0.250 Shaft		2
12	805606-00	**Label**, Operating Instructions, 12 Lead ECG Adapter, English	A,B,G	1
	805606-01	**Label**, Operating Instructions, 12 Lead ECG Adapter, French	C,D	1
	805606-02	**Label**, Operating Instructions, 12 Lead ECG Adapter, German	E	1
	805606-03	**Label**, Operating Instructions, 12 Lead ECG Adapter, Spanish	F	1
13	805334-00	**Label**, Warning/Shock Hazard, English	A,B,E-G	1
	805334-07	**Label**, Warning/Shock Hazard, French	C,D	1
14	805599-00	**Panel**, Front, 12 Lead ECG Adapter, English	A,B,G	1
	805599-01	**Panel**, Front, 12 Lead ECG Adapter, French	C,D	1
	805599-02	**Panel**, Front, 12 Lead ECG Adapter, German	E	1
	805599-03	**Panel**, Front, 12 Lead ECG Adapter, Spanish	F	1
15	805595-00	**PCB Assembly**, 12 Lead ECG Adapter (includes washer and nut for each switch)		1
16	202094-212	**Screw**, Set, Self-Locking, Knurled, Cup Point		2
17	202278-017	**Screw**, Thread-Cutting, #4 x 0.312		4
18	200804-102	**Washer**, Flat, #4, 0.312 OD x 0.031T		2

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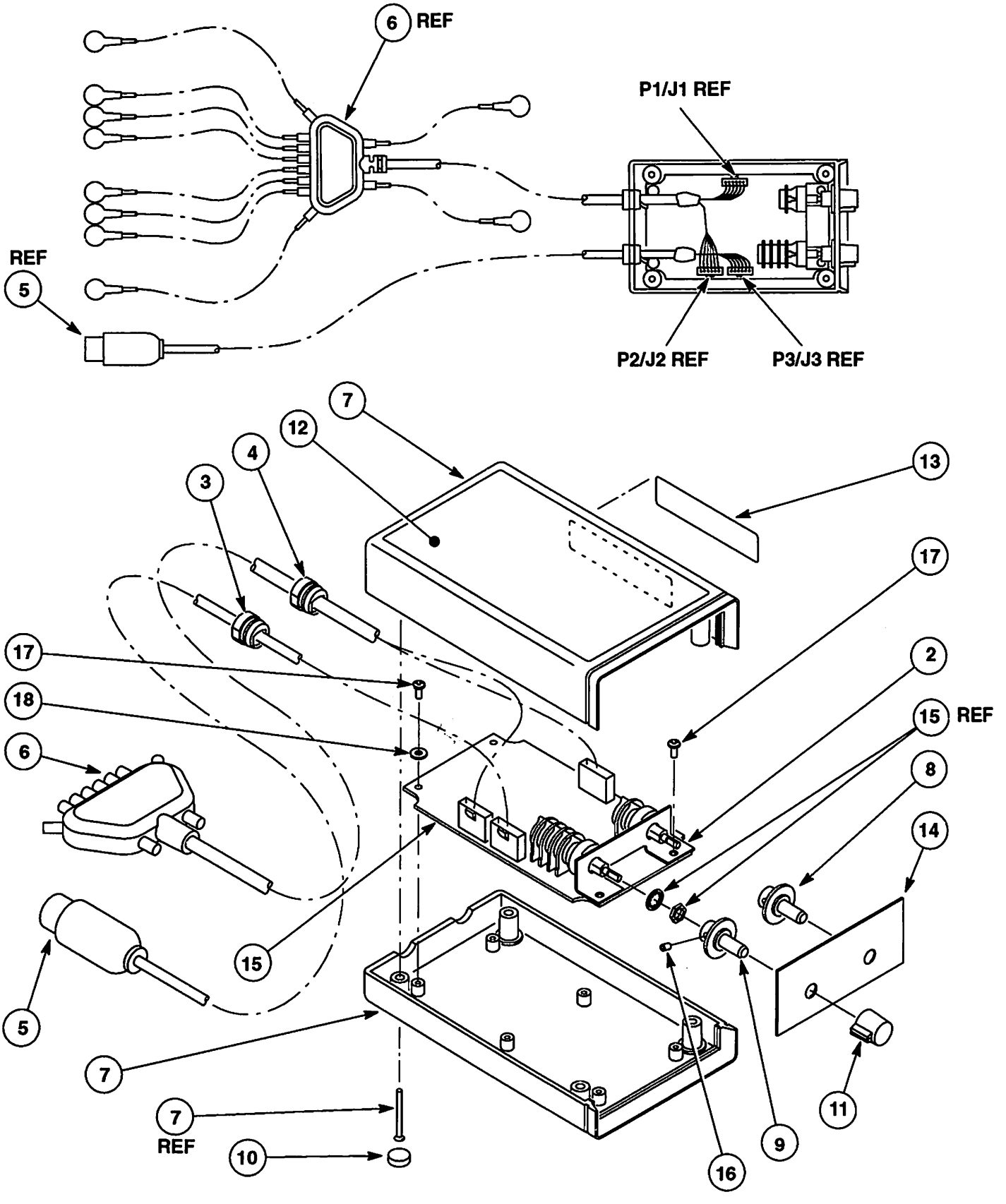

Figure 5–32 12 Lead ECG Adapter
Part Number 805600

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Component Reference Diagrams 6

Introduction

This section contains component diagrams for integrated circuits selected from the PCB assembly schematics. Each figure contains some or all of the following information as an aid in circuit analysis and troubleshooting:

- Pin Configuration
- Function Table
- Block Diagram.

Table 6–1 lists the selected integrated circuits and the corresponding reference designation and PCB assembly.

Caution

Possible Component Damage. Static Sensitive Devices (SSDs) require use of special handling procedures described on page 4–10 to prevent build up and discharge of static charge which may cause damage. The SSDs are designated with the symbol ⚠ in Table 6–1 and the parts lists in Section 5.

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Table 6–1 Selected Components

Location	Ref Des.	IC Number	Type	Fig No.	Page No.
Chart/Pacer (A2)	U4		Oscillator, Hybrid	6–18	6–12
	U6	74HC595	Shift Register, 8-Bit	6–24	6–15
	U8	HD637B01Y0P	Microcomputer	6–15	6–10
	U9	74HC138	Decoder	6–10	6–7
	U10	DS1216	Smartwatch	6–25	6–15
	U11	ADC0804	A/D Converter, 20-Pin	6–2	6–3
	U12		Gate Array, Recorder/Printhead	6–14	6–9
	U13	3843N	Pulse-Width Modulator, 8-Pin	6–21	6–13
	U24	4538BC	Multivibrator, Dual	6–16	6–11
	U29	62256LP	RAM, 256k	6–23	6–14
System (A1)	U1	3843N	Pulse-Width Modulator, 8-Pin	6–21	6–13
	U2	ADC0831	A/D Converter, 8-Pin	6–1	6–3
	U3,U8,U17, U31	74HC244	Buffer, CMOS	6–5	6–5
	U6,U40,U43	509A	Analog Multiplexer	6–4	6–4
	U7	74HC74	Flip-Flop, Dual	6–12	6–8
	U9	TLC1541	A/D Converter, 10-Bit	6–3	6–4
	U10	NMC9306NE	EEROM, 256-Bit	6–11	6–8
	U14,U28		Oscillator, Hybrid	6–18	6–12
	U15	HD637B01Y0P	Microcomputer	6–15	6–10
	U19	74HC221	Multivibrator, Dual One-Shot	6–17	6–11
	U20	HD637B01Y0C	Microcomputer	6–15	6–10
	U22		Gate Array, No Fade	6–13	6–9
	U23		Timing Hybrid	6–26	6–16
	U24		Charge Control Hybrid	6–8	6–6
	U25	7528	Buffer, Dual D/A Converter	6–6	6–5
	U27	6264LP15	RAM, 8k x 8	6–22	6–14
	U29	74HC240N	Buffer, Inverting	6–7	6–6
	U30	SG3525A	Pulse-Width Modulator, 16-Pin	6–20	6–13
	U32,U39	74C914	Trigger, CMOS	6–27	6–16
	U34	TDA1170D	CRT Deflection	6–9	6–7
	U41		Preamp Hybrid, Custom	6–19	6–12

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Figure 6–1 **A/D Converter, 8-Pin**
System (A1)

IC No. ADC0831
Ref. Des. U2

Figure 6–2 **A/D Converter, 20-Pin**
Chart/Pacer (A2)

IC No. ADC0804
Ref. Des. U11

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Figure 6–3 **A/D Converter, 10-Bit**
System (A1)

IC No. TLC1541
Ref. Des. U9

Figure 6–4 **Analog Multiplexer**
System (A1)

IC No. 509A
Ref. Des. U6, U40, U43

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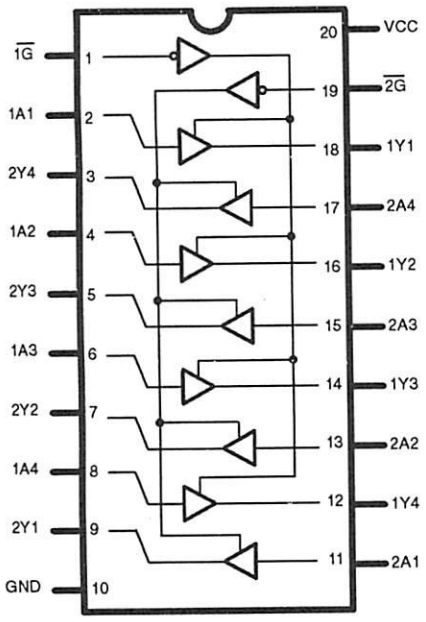
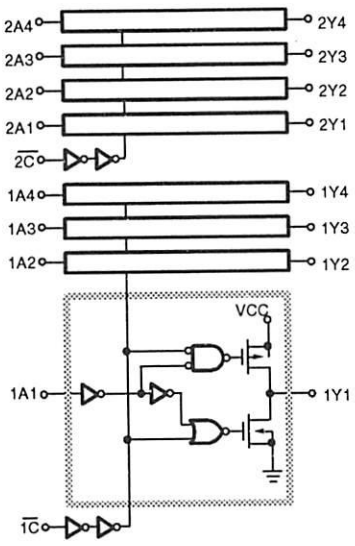
Figure 6–5 Buffer, CMOS
System (A1)

IC No. 74HC244
Ref. Des. U3, U8, U17, U31

CONNECTION DIAGRAM



FUNCTIONAL DIAGRAM



FUNCTION TABLE

1G	1A	1Y	2G	2A	2Y
L	L	L	L	L	L
L	H	H	L	H	H
H	L	Z	H	L	Z
H	H	Z	H	H	Z

H = High Level
L = Low Level
Z = High Impedance output state

Figure 6–6 Buffer, Dual D/A Converter
System (A1)

IC No. 7528
Ref. Des. U25

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Figure 6–7 Buffer, Inverting ⚠ **IC No. 74HC240N**
System (A1) Ref. Des. U29

Figure 6–8 Charge Control Hybrid
System (A1) Ref. Des. U24

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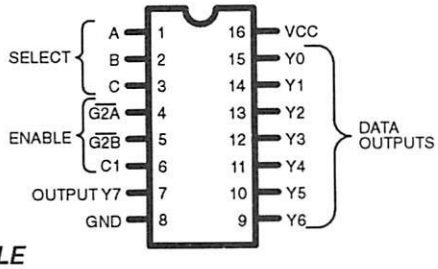
Figure 6–9 CRT Deflection System (A1)

IC No. TDA1170D
Ref. Des. U34

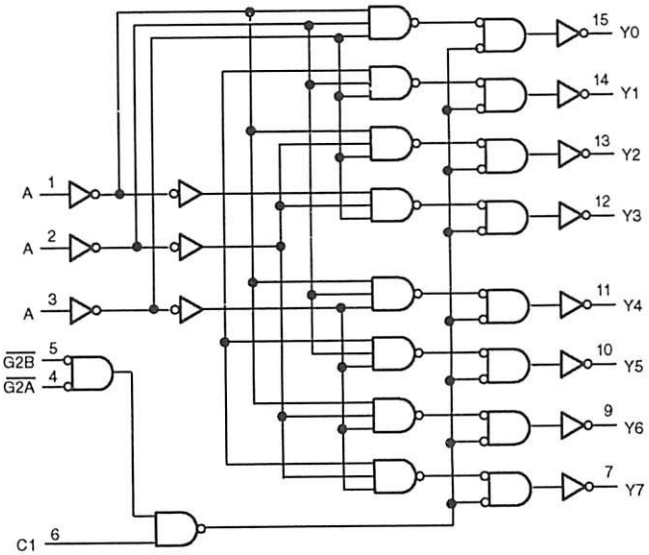
Figure 6–10 Decoder Chart/Pacer (A2)

IC No. 74HC138
Ref. Des. U9

PIN CONFIGURATION



FUNCTIONAL DIAGRAM



FUNCTION TABLE

Inputs Enable G1	G2*	Select C	B	A	Outputs Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7
X	H	X	X	X	H	H	H	H	H	H	H	H
L	X	X	X	X	H	H	H	H	H	H	H	H
H	L	L	L	L	L	H	H	H	H	H	H	H
H	L	L	L	H	H	L	H	H	H	H	H	H
H	L	L	H	L	H	H	L	H	H	H	H	H
H	L	L	H	H	H	H	H	L	H	H	H	H
H	L	H	L	L	H	H	H	H	L	H	H	H
H	L	H	L	H	H	H	H	H	H	L	H	H
H	L	H	H	L	H	H	H	H	H	H	L	H
H	L	H	H	H	H	H	H	H	H	H	H	L

*$\overline{G2} = \overline{G2A} + \overline{G2B}$
H=High Level L=Low Level X=Irrelevant

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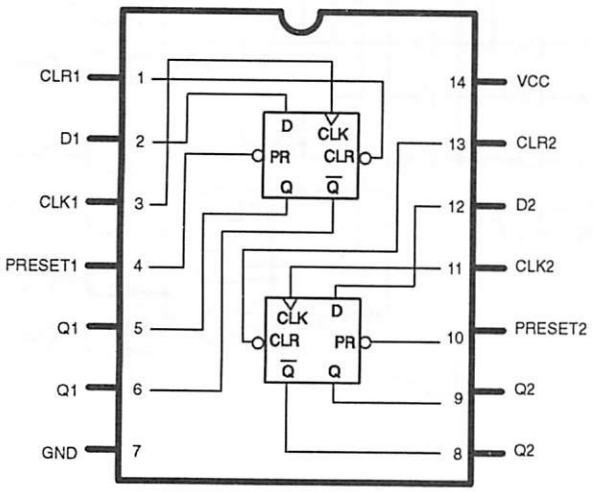
Figure 6–11 EEROM, 256-Bit
System (A1)

IC No. NMC9306NE
Ref. Des. U10

Figure 6–12 Flip-Flop, Dual
System (A1)

IC No. 74HC74
Ref. Des. U7

CONNECTION DIAGRAM



FUNCTION TABLE

Inputs				Outputs	
PR	CLR	CLK	D	Q	Q
L	H	X	X	H	L
H	L	X	X	L	H
L	L	X	X	H*	H*
H	H	1	H	H	L
H	H	1	L	L	H
H	H	L	X	Q0	Q0

H = High Level
L = Low Level
Q0 = Level of Q before steady-state conditions were established
X = Irrelevant

*This configuration is not stable; it will not persist when preset and clear inputs return to their inactive (high) level

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Figure 6–13 Gate Array, No Fade
System (A1)

Ref. Des. U22

PIN CONFIGURATION

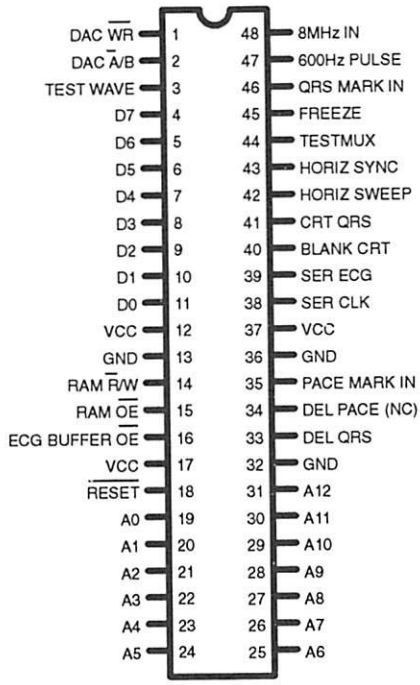

Figure 6–14 Gate Array, Recorder/Printhead
Chart/Pacer (A2)

Ref. Des. U12

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Figure 6–15 Microcomputer ⚠
System (A1)
Chart/Pacer (A2)

IC No. HD637B01Y0P
Ref. Des. U15, U20
Ref. Des. U8

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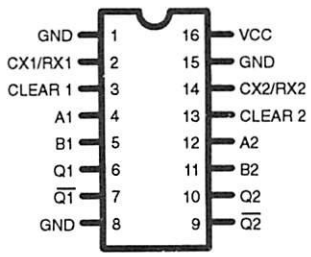
Figure 6–16 Multivibrator, Dual

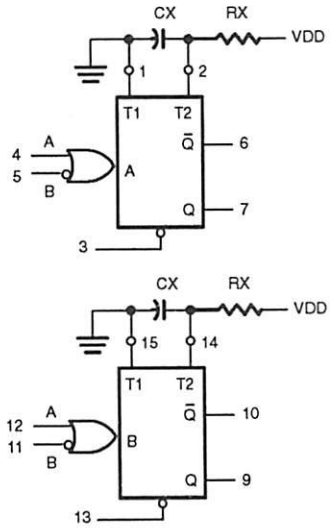
Chart/Pacer (A2)

IC No. 4538BC
Ref. Des. U24

PIN CONFIGURATION



FUNCTIONAL DIAGRAM



RX AND CS ARE EXTERNAL COMPONENTS

FUNCTION TABLE

Inputs: Clear	A	B	Outputs: Q	Q̄
L	X	X	L	H
X	H	X	L	H
X	X	L	L	H
H	L	↓	⊓	⊔
H	↑	H	⊓	⊔

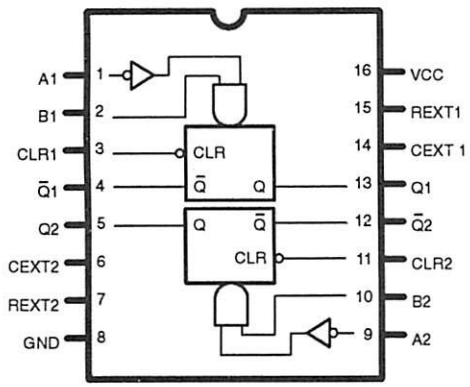
H = High Level
L = Low Level
↑ = Transition from Low to High
↓ = Transition from High to Low
⊓ = One High Level pulse
⊔ = One Low Level pulse
X = Irrelevant

Figure 6–17 Multivibrator, Dual One-Shot

System (A1)

IC No. 74HC221
Ref. Des. U19

CONNECTION DIAGRAM



FUNCTION TABLE

Inputs: Clear	A	B	Outputs: Q	Q̄
L	X	X	L	H
X	H	X	L	H
X	X	L	L	H
H	L	↑	⊓	⊔
H	↓	H	⊓	⊔
↑	L	H	⊓	⊔

H = High Level
L = Low Level
↑ = Transition from Low to High
↓ = Transition from High to Low
⊓ = One High Level pulse
⊔ = One Low Level pulse
X = Irrelevant

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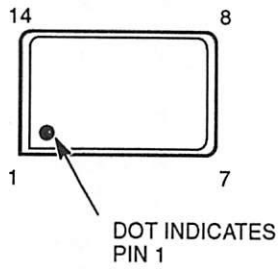
Figure 6–18 Oscillator, Hybrid

System (A1) — Ref. Des. U14, U28
Chart/Pacer (A2) — Ref. Des. U4

PIN CONFIGURATION



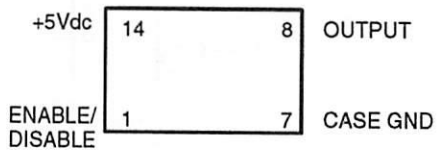


Figure 6–19 Preamp Hybrid, Custom

System (A1) — Ref. Des. U41

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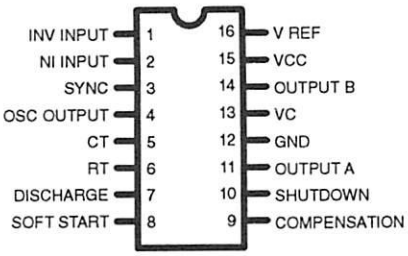
Figure 6–20 Pulse-Width Modulator, 16-Pin
System (A1)

IC No. SG3525A
Ref. Des. U30

PIN CONFIGURATION



BLOCK DIAGRAM

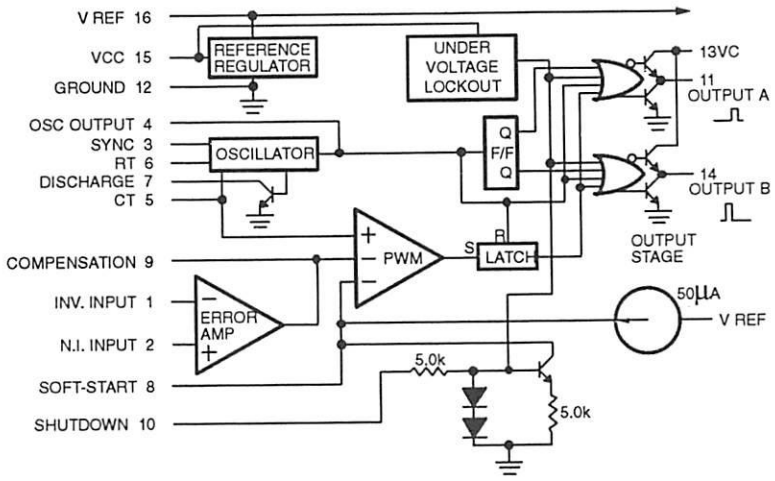


Figure 6–21 Pulse-Width Modulator, 8-Pin
System (A1)
Chart/Pacer (A2)

IC No. 3843N
Ref. Des. U1
Ref. Des. U13

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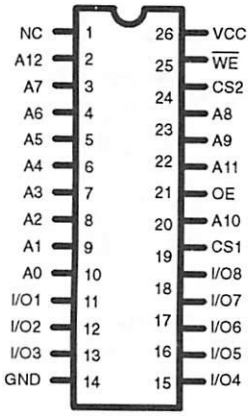
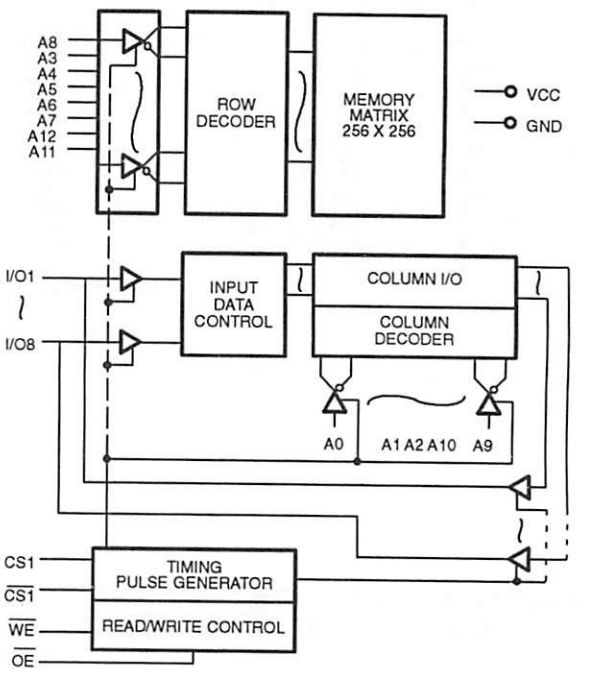
Figure 6–22 RAM, 8k x 8
System (A1)

IC No. 6264LP15
Ref. Des. U27

PIN CONFIGURATION



FUNCTIONAL DIAGRAM



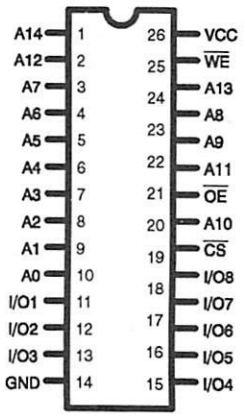
FUNCTION TABLE

WE	CS1	CS2	OE	Mode	I/O Pin
X	H	X	X	Not selected	High Z
X	X	L	X	(Power Down)	High Z
H	L	H	H	Output Disabled	High Z
H	L	H	L	Read	D out
L	L	H	H	Write	D in
L	L	H	L	Write	D in

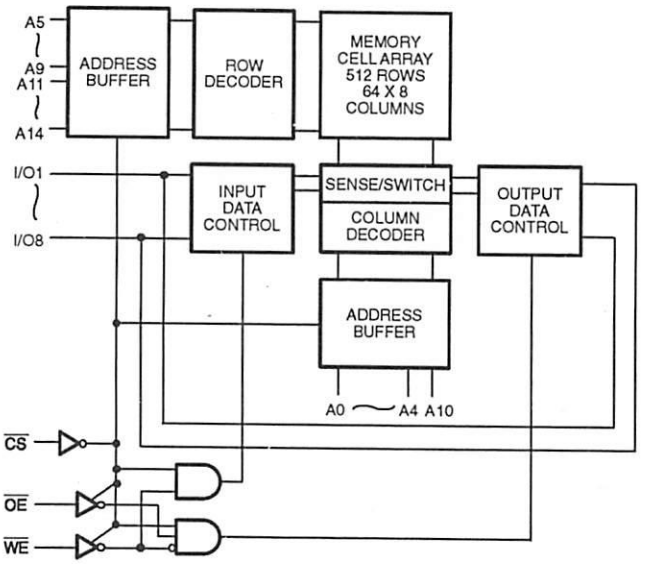
Figure 6–23 RAM, 256k
Chart/Pacer (A2)

IC No. 62256LP
Ref. Des. U29

PIN CONFIGURATION



FUNCTIONAL DIAGRAM



FUNCTION TABLE

Pin Names	Function
A0-A14	Address Input
I/O1-I/O8	Data Input/Output
CS	Chip Select
OE	Output Enable
WE	Write Enable
VCC	Power (+5V)
GND	Ground

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Figure 6–24 Shift Register, 8-Bit
Chart/Pacer (A2)

IC No. 74HC595
Ref. Des. U6

Figure 6–25 Smartwatch
Chart/Pacer (A2)

IC No. DS1216
Ref. Des. U10

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Figure 6–26 Timing Hybrid
System (A1)

Ref. Des. U23

PIN CONFIGURATION

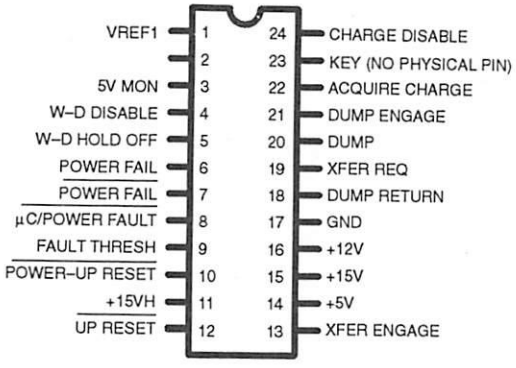

Figure 6–27 Trigger, CMOS
System (A1)

IC No. 74C914
Ref. Des. U32, U39

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